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Instruction Manual
Model NC-1
TRANSISTOR TEST SET

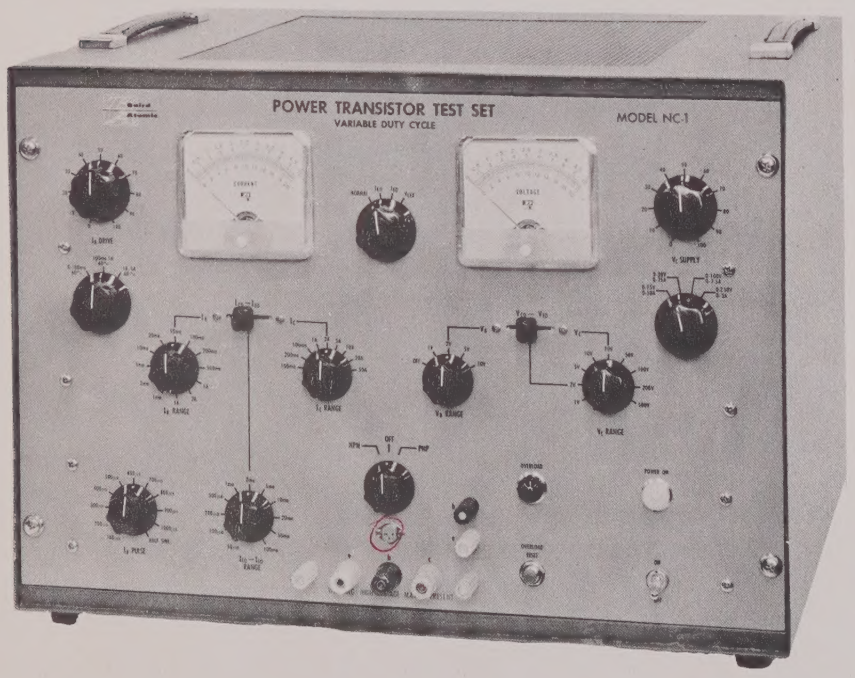
Baird-Atomic, Inc.
Cambridge, Mass. USA

Baird Atomic

Instruction Manual

Model NC-1

TRANSISTOR TEST SET



Baird Atomic

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NC1-113 Voltmeter and Ammeter Block Diagram

NC1-114 Power Supply Schematic

NC1-115 Base Current Supply and Overload Circuit Schematic

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NC1-117 Voltmeter Amplifier Schematic

NC1-118 Ammeter Shunts and Switching

NC1-119 Voltmeter Gates and Switching

NC1-120 Function and PNP-OFF-NPN Switches

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OPERATING NOTE

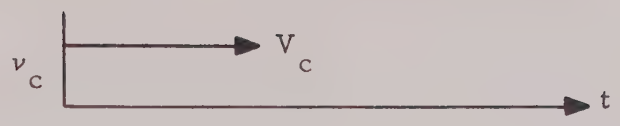
This instrument has several line-operated power supplies. Appreciable power may be drawn from the line during a small fraction of a cycle of supply voltage. Proper operation requires a low noise AC power line of moderately good regulation. If such a line is not available, the instrument will operate better if a constant voltage transformer of 500 VA capacity (such as the Sola Electric type 22-150 CA or equivalent) is used.

SECTION I
INTRODUCTION

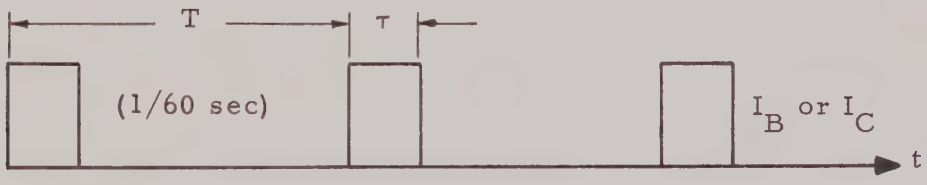
A. The NC-1 is a direct reading, variable duty cycle, medium and high power transistor test set. It has two modes of operation: the active mode makes tests for amplification, and the cutoff mode tests for I_{CO}, I_{EO}, and V_{CEX}. The Function Selector switch selects the mode of operation.

In the active mode, the transistor is biased for conventional circuit operation. Forward current gain, input resistance, etc., can be measured. These readings are obtained by applying pulse drive signals to the base of the transistor (which is connected in the common emitter configuration) and then peak-detecting the resulting base and collector current pulses so that they have the same measuring value as steady-state DC. As a consequence of this testing method, all high power parameters are measured at a considerable saving of average input power, thus minimizing the need for elaborate power-dissipating media.

The low average power is achieved as follows. During the normal test mode, steady DC voltage is applied to the collector.



However, the base drive current is pulsed as shown:



The resulting collector current pulses are a close reproduction of the base input signal. As shown in the Appendix, the average input power for the case of steady collector voltage and pulses of current is considerably lower than would result from conventional steady voltage and current.

The average input power is defined as:

$$\overline{P}_{in} = \frac{1}{T} \int_0^{\tau} E(t)\, I(t)\, dt$$

By integrating:

$$\overline{P}_{in} = V_C\, I_C\, D$$

where D is defined as the duty factor. Numerically tabulated values of D in the Appendix can be used in conjunction with meter readings of V_C and I_C to calculate average input power.

For rectangular current pulses, the limiting factor on pulse width is the response speed of the transistor under test. In typical NC-1 operation D is .01 to .03. With the duty cycle at this low figure, power dissipation is around 1% to 3% of the amount it would be if steady DC were applied to the transistor. This permits measurements at high power levels which, if conventional DC measurements were used, would normally damage the transistor.

The leakage parameters I_{CO}, I_{EO}, and V_{CEX} are tested by conventional methods. These readings are obtained at a low power level with the transistor under test biased by steady state DC.

B. Specifications

AC Power Input

117 Volts, 60 cycles per second

Approximately 300 Volt Amperes

Base Drive Supply

Pulse Selector

Choice of 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 μsec rectangular pulses at 60 cps repetition, or half wave rectified sine pulses. Accuracy on rectangular pulse width is 5%.

Note - These pulse widths produce a range of duty cycle from 0.006 to 0.25.

Range Switch

10 ma (5V maximum across 500 Ω)

100 ma (20 ma half sine) (5V maximum across 50 ohms)

1A (10V maximum across 10 ohms)

5A (3A half sine) (10 V maximum across 2 ohms)

Drive Adjustment

Continuous control of pulse amplitude

Collector Supply

Range Switch

0 - 15 V up to 50 A

0 - 30 V up to 25 A

0 - 100 V up to 7.5 A

0 - 250 V up to 3 A

Voltage Adjustment

Collector voltage is continuously adjustable from zero to maximum.

Voltage Regulation

15 and 30 V Ranges

Collector supply impedance approximately 1/10 ohm.

100 and 250 V Ranges

Collector supply impedance approximately 2 ohms.

Power Output

The collector supply will deliver 750 watts peak in any shaped pulse. At the widest pulse, the half wave rectified sine, the collector supply will deliver 175 watts continuously.

Ammeter

The ammeter peak detects the current pulses so that they have the same measuring value as steady DC. The current is read on a 3" meter.

Base Current Ranges

1, 2, 5, 10, 20, 50, 100, 200, 500 milliamperes and 1, 2, 5, amperes full scale

Collector Current Ranges

100, 200, 500 MA, 1, 2, 5, 10, 20, 50 amperes full scale

Leakage Current Ranges (I_{CO}, I_{EO}, V_{CEX})

50, 100, 200, 500 microamperes, 1, 2, 5, 10, 20, 50, and 100 milliamperes; jack for plugging in external meter.

An ammeter selector switch is provided for switching the ammeter into the desired circuit.

Accuracy ±3% on all ranges

Voltmeter

The voltmeter reads the voltages obtained during the current pulse time. These voltage pulses are peak detected so that they have the same measuring value as would steady DC. The voltage is read on a 3" meter.

Base Voltage Ranges

1, 2, 5, 10 volts full scale

Collector Voltage Ranges

1, 2, 5, 10, 20, 50, 100, 200, 500 volts full scale

A voltmeter selector switch is provided for switching the voltmeter into the desired circuit.

Accuracy

± 3% on all ranges

Function Selector

Front panel control with the following positions -

Normal (Pulse drive applied to test transistor which is biased in the active mode as it would be for usual circuit operation)

I_{CO}
I_{EO}
~~I_{CO}~~
V_{CEX}

(Leakage Measurements - conventional steady DC applied to test transistor)

The function selector switch applies the proper currents and voltages to the test transistor in each position.

PNP - OFF - NPN Switch

A front panel switch reverses power supply polarities for testing of PNP or NPN transistors without changing connections. In the OFF position, all voltages are removed from the test transistor.

Automatic Overload

An automatic overload is provided to remove collector voltage whenever the collector current exceeds twice the setting of the collector ammeter range switch. Front panel overload indicator and reset control.

Construction

Ruggedly constructed to stand up in lab usage.

All components conservatively derated, capable of continuous operation at maximum power.

Possible Uses

Power transistor DC current gain, saturation measurements, input and output impedance, leakage current, breakdown voltage. Also, diode leakage and breakdown measurements.

SECTION II
BLOCK DIAGRAM DISCUSSION

The NC-1 circuitry can be divided into two principal sections. One group of circuits, the power supplies and switching, provides operating voltages of the required polarities to the transistor under test; the second group transmits the test results from the transistor to the meters. This second group is composed of the ammeter and voltmeter circuitry. The two block diagrams (NC-1-112, Power Supplies and NC-1-113 Metering Circuits) show the respective circuitry. A simplified block diagram, Fig. II-1, shows the basic principle of the instrument.

Power Supplies and Switching

Base and Overload Power Supplies. These are composed of transformers T101 and T102 and their associated circuitry. They provide low voltage DC for the transistors in the Base Current Pulse Generator and the Collector Overload circuit. In addition, the Base Power Supply sends a "base enable" signal and a half-sine pulse to the Base Current Pulse Generator. Both these pulses are 60 cycle half wave rectified sine signals. The "base enable" signal has an approximate 88° forward phase shift. This signal is used to initiate the base current multivibrator.

Base Current Pulse Generator. This circuit develops the base drive signal and the voltmeter enabling gate. The sinusoidal base enable signal (which has 88° of advance) is rectified by CR206 and then sharpened by Q206 and Q207. The differentiated, shaped pulse drives a one-shot multivibrator of variable width. The pulse width selector picks either a rectangular pulse or the half-sine pulse for routing to the driver. Four ranges of base drive are provided: 10 MA, 100 MA, 1A, and 5A. The base current signal is of variable width and amplitude.

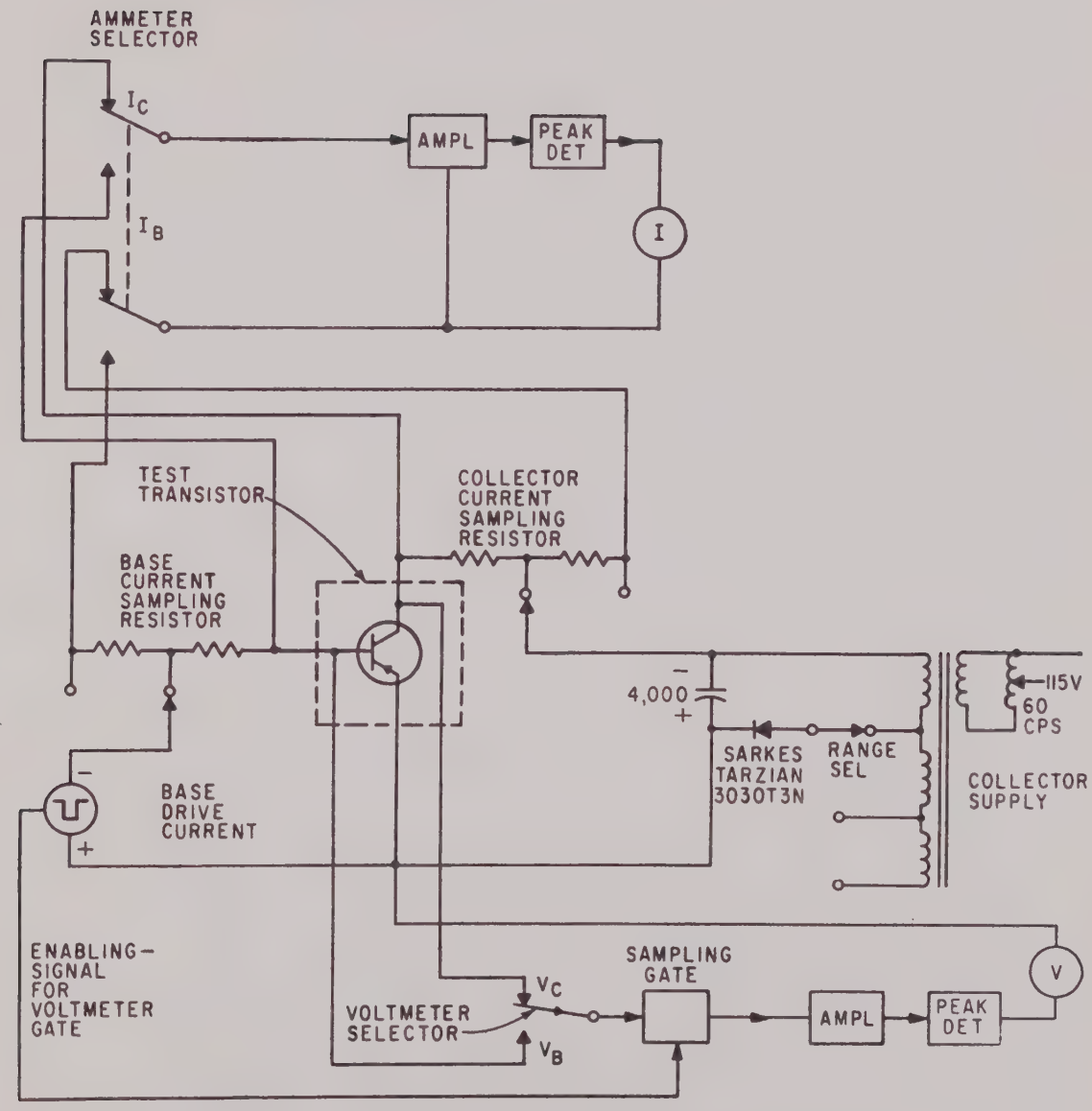

AMMETER SELECTOR
I_C
I_B
AMPL
PEAK DET
I
TEST TRANSISTOR
COLLECTOR CURRENT SAMPLING RESISTOR
BASE CURRENT SAMPLING RESISTOR
4,000
SARKES TARZIAN 3030T3N
RANGE SEL
115V
60 CPS
COLLECTOR SUPPLY
BASE DRIVE CURRENT
ENABLING SIGNAL FOR VOLTMETER GATE
SAMPLING GATE
V_C
VOLTMETER SELECTOR
V_B
AMPL
PEAK DET
V

Figure II-1

The pulse width is selected by S201, the I_B PULSE control. Amplitude is controlled by four position Drive Range Switches 202; R202 provides continuous control.

Collector Overload. The overload circuit monitors the collector current pulse. When the current reaches 200% (X2) of the I_C RANGE switch setting, the relay K201 operates. This removes AC power from the primary of T105 and T106, the V_C supply transformers. The relay stays in this position until reset by S203, the OVERLOAD RESET control.

Collector Voltage Adjustment (T107). This auto transformer controls the input voltage on the primary of T105 and T106, the collector supply transformers.

Voltage Range Switch (S102). Sections A, B, and C of this switch select the proper transformer windings for the desired voltage range. The windings of T105 and T106 are connected in various adding and bucking modes. Section D selects the correct RC filter network for the voltage range selected. Sections E and F are electrically in the Voltmeter Range Switching circuits. These switch the inputs and outputs of the high and low voltage collector voltage sampling gates.

Collector Power Supply (T105, T106). This supply is composed of a half wave rectifier with a capacitor input filter. It generates the collector voltage for the transistor under test.

Base Current Range (S502). The range is controlled by the twelve-position I_B RANGE switch. This switch selects the correct shunt for measurement of the base current pulses.

I_{CO} - I_{EO} Range (S503). This is an eleven-position switch which selects shunts for the direct DC measurement of the various leakage currents.

Collector Current Range (S504). The I_C RANGE control is a nine-position switch for selecting shunts to measure the collector current pulses.

Function Selector (S701) and PNP-OFF-NPN (S702). These switches route the correct potentials to the test jacks for the various modes of operation and types of transistor. When the Function Selector is in the normal mode, both the base and collector power supplies are used. When this switch is in any of the three leakage mode positions, the base supply is not used and the variable collector supply provides all the bias voltages for the leakage tests.

Since the voltmeter circuits require a fixed polarity input, the PNP-OFF-NPN switch adapts the voltage from the test jacks to provide a constant polarity at the voltmeter input.

The collector voltage readings in the normal mode may be taken in two ways: at the output terminals or directly at the test transistor terminals. The latter is necessary since voltage drops in test fixture wiring at the 50A level can cause appreciable error.

The voltage reading $V_{CO} - V_{EO}$ is taken at its power supply. This is possible because the relatively low current drain of this supply does not produce significant voltage drops in the internal wiring.

METERING CIRCUITS

Ammeter Selector (S501). This three position switch selects the reading to be displayed on the ammeter. These readings are for I_B, $I_{CO} - I_{EO}$, and I_C. The $I_{CO} - I_{EO}$ readings are obtained from steady state DC and are applied directly to the meter. The I_B and I_C readings are obtained from pulses which must be amplified and peak detected before applying to the meter. The I_B and I_C pulses are obtained across their respective tapped shunts. The ammeter and its power supply float across the whole measuring shunt.

Ammeter Amplifier and Ammeter Power Supply (T103). The I_B and I_C pulses are " conditioned" in the amplifier for presentation on the meter. At 50V full scale output and a gain of 500, .1V is needed at the input. Feedback holds the gain constant over a wide range of line voltage and component tolerances.

The amplifier circuit output is peak-detected and applied through S501 to the meter. The meter reads an apparent DC corresponding to the peak of the input signal.

The power supply provides the necessary operating voltages.

Voltmeter Selector (S601). The three positions of this switch select readings for V_B, $V_{CO} - V_{EO}$, and V_C. The base voltage is a virtual reproduction of the current pulse and is applied directly through the V_B RANGE Control and S601 to the voltmeter amplifier.

The collector voltage measurement is achieved as follows. If either $V_{CO} - V_{EO}$ or V_C is selected, S601B routes this signal to S102E (the collector supply range switch). The output of S102E is sent to the low voltage gate when the 0 - 15 volt range is selected; the output of S102E is applied to the high voltage gate on all other ranges. The outputs of the gates are routed to S102F where the appropriate one is then sent to S603, the V_C range switch.

High and Low Voltage Gates. Both gates are saturated amplifiers, gated open during the collector current pulse interval. The I_B PULSE control varies the width of the enabling gate to the amplifiers. The collector voltage shown on the voltmeter is the actual voltage across the transistor while current is drawn.

The low voltage gate, Q601, is gated open by the negative enabling gate from T601. The high voltage gate (V603A) is gated open by a negative

gate from amplifier V603B; V603B is in turn driven by T601, positive enabling gate.

The voltmeter enabling gates are obtained from T601, which is in turn driven by Q210. An RC integrator in the base of Q210 delays the leading edge of the voltmeter enabling gate until 20 μs after the start of the base drive pulse. This allows the test transistor to reach full current before voltage is sampled.

V_B RANGE and V_C RANGE (S602, S603). These switches attenuate the base voltage or the gated collector voltage sample according to the full scale setting. The scale factor is such that one volt will drive the voltmeter to full scale output.

Voltmeter Amplifier and Voltmeter Power Supply. The voltage pulse input is amplified and peak detected, then fed to the meter. The meter reads an apparent steady-state DC voltage. The gain is 20 and stabilized by feedback.

Necessary voltages are provided by the power supply.

SECTION III
CIRCUIT DESCRIPTION

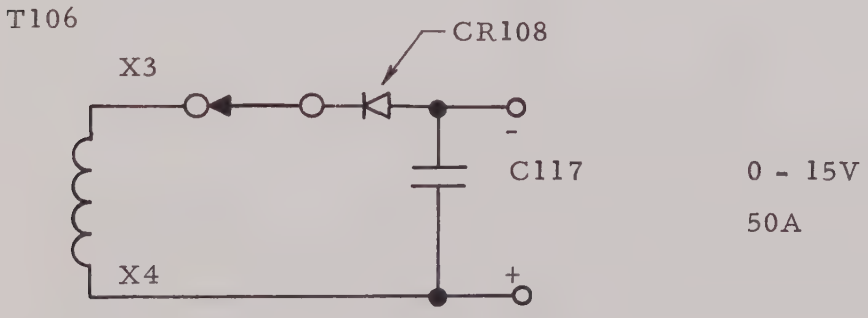
Power Supplies

The power supplies in the NC-1 are all conventional circuits. The block diagrams and wiring schematics show the voltages generated and the functions served by the various outputs.

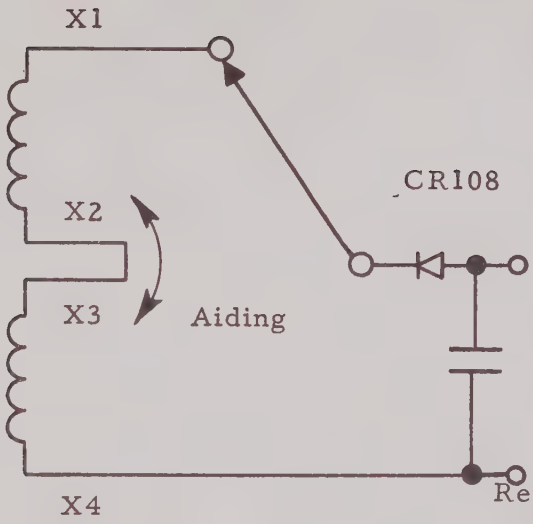
The phase shift adjustment R102 and C101 provides an 88% forward phase shift. This allows the fastest rising portion of the sine wave i.e., zero axis crossing ("base enable" signal) to generate the enabling gate.

Depending on the range selector, the autotransformer T107 adjusts the collector voltage between zero and maximum. The V_C SUPPLY range switch S102 has four ranges for selection of collector current and voltage. Two sections of S102 are electrically in the voltmeter switching circuits. These two sections serve to switch the voltmeter between the high and low voltage gates.

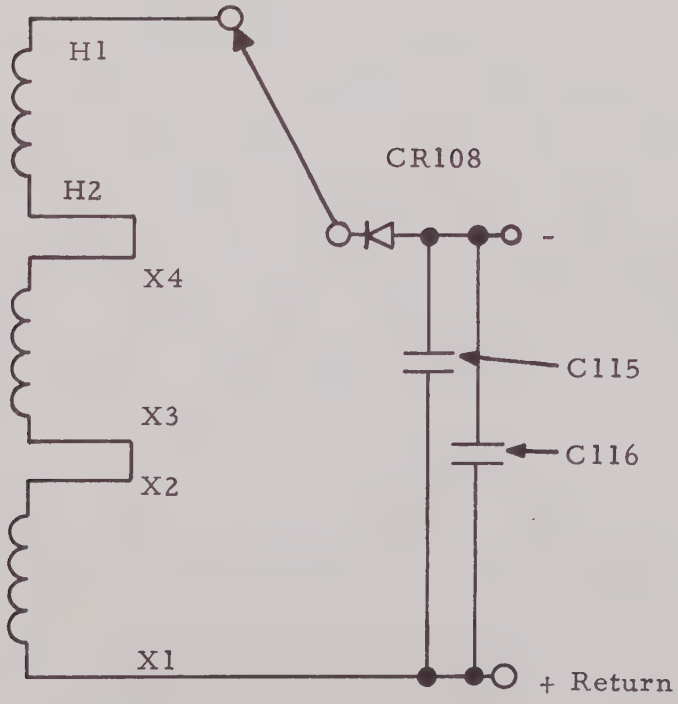
T105 - 106 winding connections are shown for the various collector supply ranges.



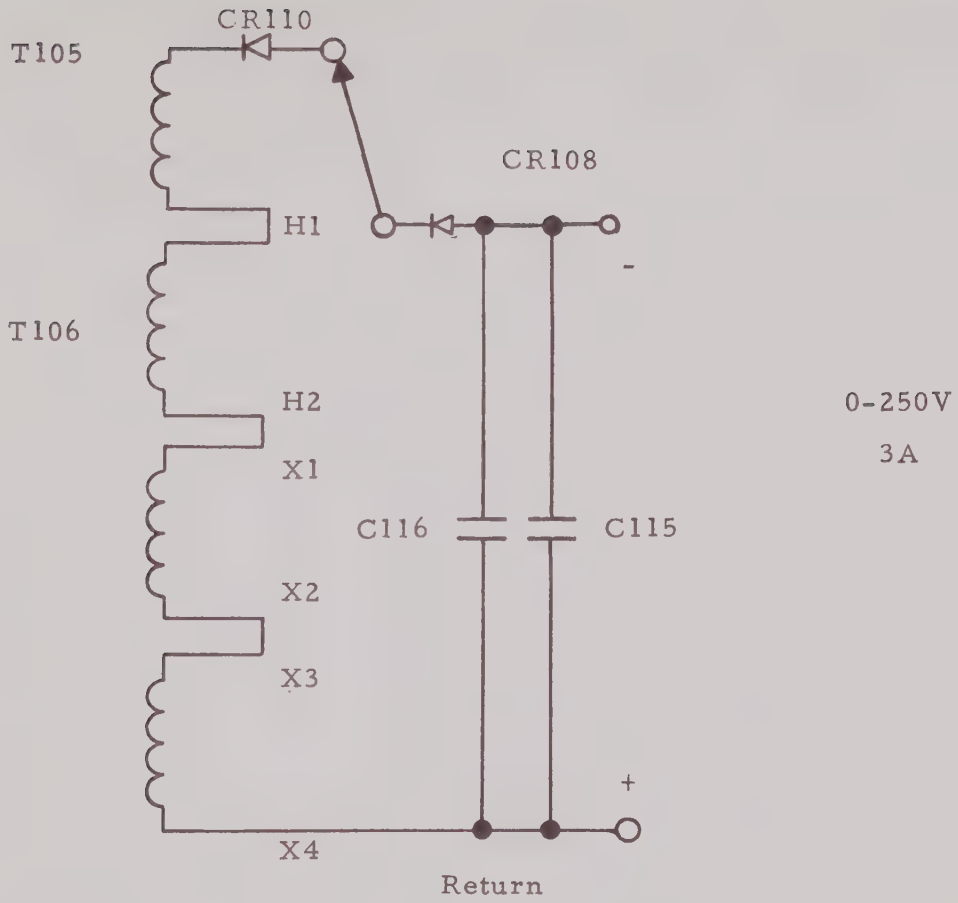
T106



T106



Note: X1 to X4 bucks H1 to H2.



Note: All windings aiding

Base Pulse Generator

The enable signal is amplified and given a fast leading edge by Q206 and Q207. After differentiation by C207 and R211, the pulse triggers the one shot multivibrator Q208 and Q209. The output of the MV goes to S201D and Q210.

The I_B PULSE control S201 selects the pulse width desired. Q210 drives T201, the transformer supplying the low and high voltage enabling gates to operate the voltmeter gating circuits.

S201D selects the MV pulse, or the sine pulse, for application to the test transistor. The selected signal is applied to the base of Q201, an emitter

follower. The potentiometer in the emitter of Q201 is used to drive the bases of Q202 and Q203. Q202 is used to supply the base current on the 0-100 MA range. Q203 is used to supply current on the 100 MA to 1A range. On the 1A to 5A range, Q203 is operated as an emitter follower to drive Q204 and Q205, which supply the load current. On all ranges there is protective resistance in series with the driver transistors so that the base current generator will safely operate into a short circuit.

Collector Overload

The overload operates when the collector current reaches twice that of the I_C RANGE setting. This circuit can operate only in the normal mode; it is inoperative during leakage mode measurements.

The collector ammeter is deflected full scale by a 0.1 volt peak-to-peak signal. CR202 conducts when a 0.2 volt signal appears on its anode, applying 0.1 volt to the base of amplifier Q211. The signal is applied to emitter follower Q212, and rectified by CR204. Amplifier Q213 drives Q214, thus closing the normally unoperated overload relay K201. The relay removes supply voltage from the primaries of the collector power supply.

Ammeter

The input signal to the amplifiers V301 and V302 consists of a 0.1 volt negative peak-to-peak signal. This is amplified to 50V. This feedback amplifier has a gain of 500, set by R308 and R314.

The 50V output is DC restored by V303A, then rectified and peak detected by V303B and C305. The detected signal is fed through S501 to the ammeter.

Voltmeter

This is a feedback amplifier with a gain of 20, set by R406 and R408. The IV positive peak-to-peak input is amplified to 20V by V401 and V402. The

amplifier output is DC restored by CR402 and peak detected by CR401 and C405. The detected signal is fed directly to the voltmeter.

Ammeter Range Switching

The switching circuits select the ranges for the type of information fed to the meter.

Voltmeter Range Switching

These circuits select the type of information fed to the meter. The high voltage gate consists of V601, while Q601 serves as the low voltage gate. Both these gates are saturated amplifiers, gated open during the enabling pulse.

The high voltage gate is in operation when S102, the V_C SUPPLY range switch, is in one of its three upper ranges (0 - 30V, 0 - 100V, 0 - 250V). The low voltage gate operates only when S102 is in its lowest range (0 - 15V).

SECTION IV
OPERATING INSTRUCTIONS

Operating Precautions

Inserting and Removing Test Devices. When operating at high power levels, never insert or remove a transistor or diode at the test jacks without lowering the power level beforehand. Considerable stored energy is present in the filter circuit of the V_C power supply, and a sudden inrush of this energy can damage the device under test. Always reduce the I_B DRIVE and then the V_C SUPPLY to zero before plugging in or removing the device under test.

Changing Switch Settings. NEVER use the PNP-NPN switch to remove high power from the test transistor. NEVER rotate the function selector switch S701 with high power applied to the transistor. The I_B DRIVE and V_C SUPPLY may be safely reduced to zero by backing R202 and T107 full counter-clockwise.

Maximum Voltage Readings. When operating near the breakdown or maximum voltage rating of the device under test, the collector current should be set to zero before maximum voltage is applied.

As current is drawn, some voltage will be dropped in the internal resistance of the collector power supply. Since current is drawn in pulses and the voltmeter reading is gated to coincide with the current pulse, a higher voltage may be present than is indicated on the meter during the intervals of nonconduction. Setting the collector voltage with zero collector current assures that the maximum voltage will never be exceeded.

Maximum Current Readings. Never exceed the manufacturer's maximum current ratings for the device under test. High peak currents with seemingly low average values may cause the device to fail even though it

may still be cool to the touch. This is because the junction has a very short thermal time constant, on typically the order of a few milliseconds. The high peak pulses cause excessive local junction overheating with ensuing device failure.*

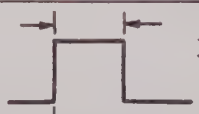
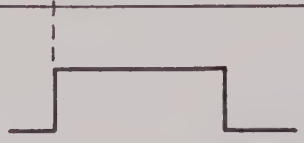
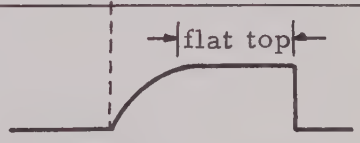
Optimum Pulse Width. Unless testing to a specific standard, always use the narrowest pulse width consistent with the response speed of the device tested. Many power transistors now available have a response too slow for the 100 μsec pulse width.

NOTE

> The accuracies obtainable on the 100 μsec range are approximately one-half those on other ranges. Therefore it is suggested that an oscilloscope be used to monitor the desired parameters when using the 100 μsec pulse width.

A simple method of checking for correct pulse width is to start with 200 μsec, then keep raising the pulse width until the collector current ceases increasing with each increase in width. The correct pulse width is that switch position where collector current ceases increasing.

A more accurate check is obtained by using an oscilloscope to observe the collector current pulse shape. To be usable, the current pulse should have a reasonably flat top section.

	Base Pulse	Collector Current Pulse
Narrow base pulse. Current pulse shows poor response.		
Base pulse at correct width. Current pulse top shows proper response.		

*A study of junction heating under pulse conditions is given by K.E. Mortenson "Transistor Junction Temperature as a Function of Time," Proceedings of the IRE, Vol. 45, No. 4, April 1957, and "Rating Transistors for Pulse Operation," H. L. Morgan, Electronic Equipment Engineering, June 1960, p.97

Active Mode Measurements

Power ON. Turn power on with switch S101 and allow a 5-minute warm-up period.

NOTE

Whenever the power is turned on, the overload light will come on. Reset before using the instrument. This feature is incorporated to provide the operator with verification that the overload circuit is working properly.

H_{FE} Measurement Procedure

Before performing any measurements observe the following general notes of precaution :

1. SENSING LEADS - VC MEASUREMENTS

Jacks J1, J2 and J3 are used to supply the test transistor with proper operating biases. Jacks 7 and 8 are provided to couple the collector voltage to the voltmeter. The instrument is shipped from the factory with a set of shorting wires between J1 and J7 and J3 and J8. Thus, the collector voltmeter reads the voltage between J1 and J3. This measurement is sufficiently accurate when the leads to the test transistor are short and the collector current is low. However, when the voltage drop in the leads from J1 and J3 to the test transistor becomes appreciable (as, for example, in saturation measurements), separate sensing leads may be used. When using these separate sensing leads, disconnect the shorting wire between J1 and J7, and J3 and J8. Connect a lead between the emitter of the test transistor and J7; also between the collector of the test transistor and J8. These sensing leads should be connected right at the collector and emitter terminals for greatest accuracy.

2. LOW LEVEL NOTE

On the lowest ranges of current and voltage, notably in the base circuit, the meters may read approximately .1 to .15 of full scale with base drive backed to zero. This is caused by noise pickup and does not affect the accuracy of the measurements. A reading of .25 scale gives a signal-to-noise ratio of approximately 2:1, which for peak detection is sufficient to pull the signal out of the noise.

3. NOTE

TAKE VOLTMETER AND AMMETER READINGS IN THE UPPER 75% OF THE SCALE; READJUST THE RANGE IF THE INDICATOR FALLS IN THE LOWER 25% OF THE FULL SCALE.

WARNING

Perform steps 1 through 8 below without the transistor in the test socket.

1. Turn the NPN-OFF-PNP switch to the position corresponding to the polarity of the device under test.
2. Set the Function Switch at Normal.
3. Turn both the I_B DRIVE and V_C SUPPLY to zero.
4. Set the four-position DRIVE RANGE switch on the range covering the approximate base drive; always use lowest possible range.
5. Set the four-position VOLTAGE RANGE switch to the desired setting. Always use the lowest possible range since this will give the best voltage regulation.
6. Move the Ammeter Selector to I_C; move the Voltmeter Selector to V_C.
7. Set I_C RANGE to the approximate current.
8. Set V_C RANGE to the approximate voltage.

9. Plug the test transistor into the appropriate socket (J1, J2, J3 or J6).
10. Obtain the correct collector voltage by adjusting V_C SUPPLY.
11. Adjust I_B DRIVE for the correct collector current. As current is drawn, V_C will drop slightly due to the internal impedance of its power supply. Readjust V_C SUPPLY as required to obtain the correct operating voltage.
12. Read and record the value of I_C.

To measure Saturation $V_{BE(SAT)}$ & $V_{CE(SAT)}$
start @ zero setting

1st - Apply the Base drive & adjust
I_B to the specified current.

2nd Throw I_B-I_C switch to I_C.
Adjust the I_C range to specified
current range. Then turn the
collector voltage adjust slow
while watching the current
meter - when the specified cur
is indicated, flip the I_B-I_C
back to I_B and recheck the
current (which usually will drop
when I_C was adjusted - now a
touch the knobs, but read the base
voltage and the collector voltage

13. Move the ammeter selector to I_B and, using the I_B Range control, read I_B.
14. Calculate H_{FE} as I_C/I_B.
15. When testing is completed, adjust I_B DRIVE and V_C SUPPLY to zero before removing the transistor from the test socket.

Procedure for Obtaining Input Resistance

1. Perform steps 1 to 11 and 13 above. Record I_B.
2. Move the voltmeter selector switch to V_B. Read and record V_B.*
3. Calculate input resistance V_B/I_B.

Saturation Measurements. Measurements of collector saturation voltage are made as follows:

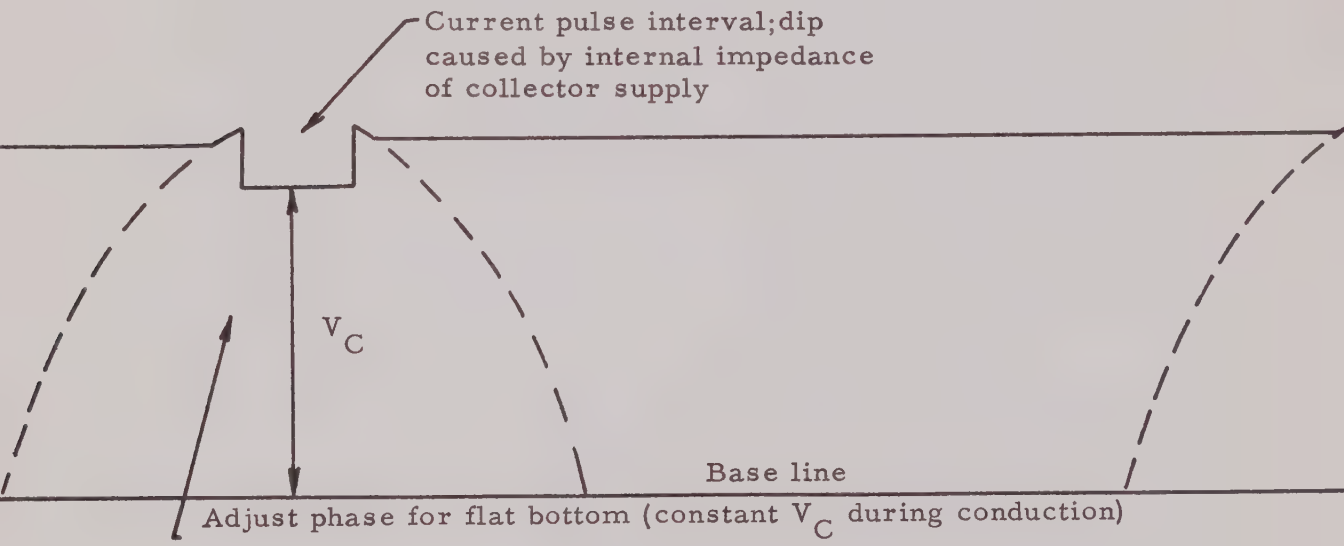
1. Perform steps 1 through 9 of the H_{FE} test procedure. Make sure that the collector supply is set to zero before proceeding.
2. Set the base drive current to the desired level. Best accuracy will result at wider pulse widths; in no case should a pulse width less than 300 μsec be used for saturation measurements.
3. Switch the ammeter selector to the collector circuit (I_C) and slowly increase the collector voltage until the desired collector current is reached. Use the 0-15V range to obtain best control.
4. Using separate voltage sensing leads, measure the collector saturation voltage right at the test device terminals.
5. Accurate saturation measurements at high currents (5A or above) require careful setting of the phase control on the rear panel. Use

*In order to prevent the ammeter from loading the voltmeter and vice versa on low level base circuit measurements ($V_B < 2V$ with $I < 20$ ma), proceed as follows:

1. While V_B is being read, move ammeter selector to $I_{CO} - I_{EO}$.
2. While I_B is being read, move voltmeter selector to $V_{CO} - V_{EO}$.

an oscilloscope to check the saturation waveform and optimize the phase setting. The oscilloscope display of collector voltage is shown below on an expanded sweep.

The phase control (R102, rear panel) should be set to give the flattest bottom (constant V_C) during the current pulse. After adjustment, the oscilloscope is no longer required.


Current pulse interval;dip caused by internal impedance of collector supply
V_C
Base line
Adjust phase for flat bottom (constant V_C during conduction)

Leakage Mode Measurements

The three leakage mode positions of the Function Switch are I_{CO}, I_{EO}, and V_{CEX}. In the V_{CEX} position readings can be obtained for V_{CER} and I_{CER}, V_{CES} and I_{CES}, V_{CEO} and I_{CEO}.

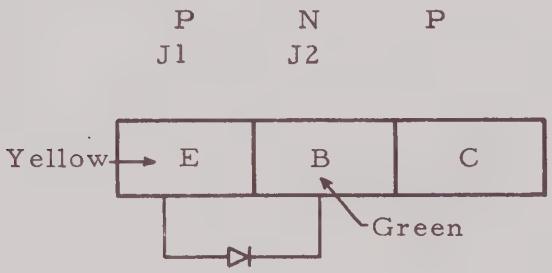
I_{CO} Measurement Procedure

1. Turn NPN-OFF-PNP switch to appropriate position.
2. Set the Function Selector switch to I_{CO}.
3. Turn the V_C SUPPLY to zero; set the V_C SUPPLY Range switch to the appropriate range.

V_{CES} - I_{CES} Measurements. Same procedure as for V_{CEO} - I_{CEO}, but connect short circuit between J4 and J5.

Diode Reverse Current Measurements

1. Turn the NPN-OFF-PNP switch to PNP.
2. Move the Function Selector switch to I_{EO}.
3. Perform steps 3 to 7 of the I_{CO} measurement procedure.
4. Plug the diode into the emitter and base sockets as shown below.
5. Raise the V_C SUPPLY until the voltmeter reads the correct reverse voltage.

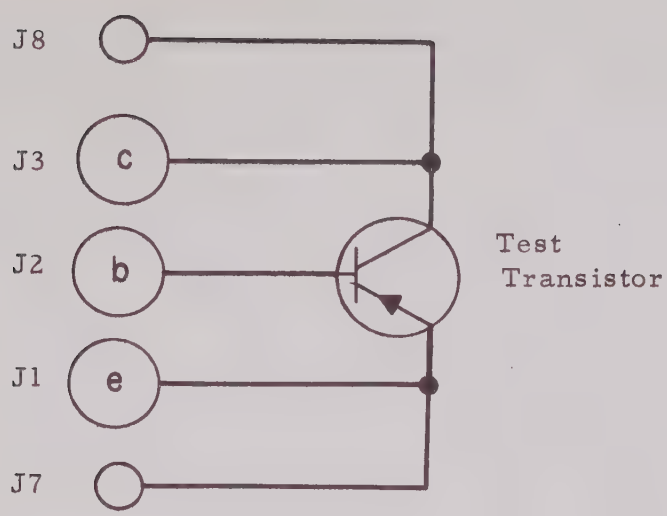


Special Applications

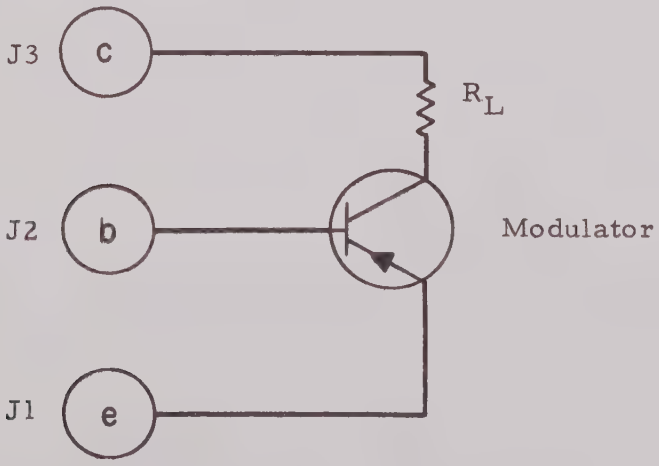
Diode Forward Drop Measured by the Pulse Method

By use of a suitable external transistor, the NC-1 may be used to measure forward drop of diodes up to a 50-ampere capability. The power savings are considerable. Device dissipation can be held to 2% of the dissipation that would result if steady or unfiltered DC were used.

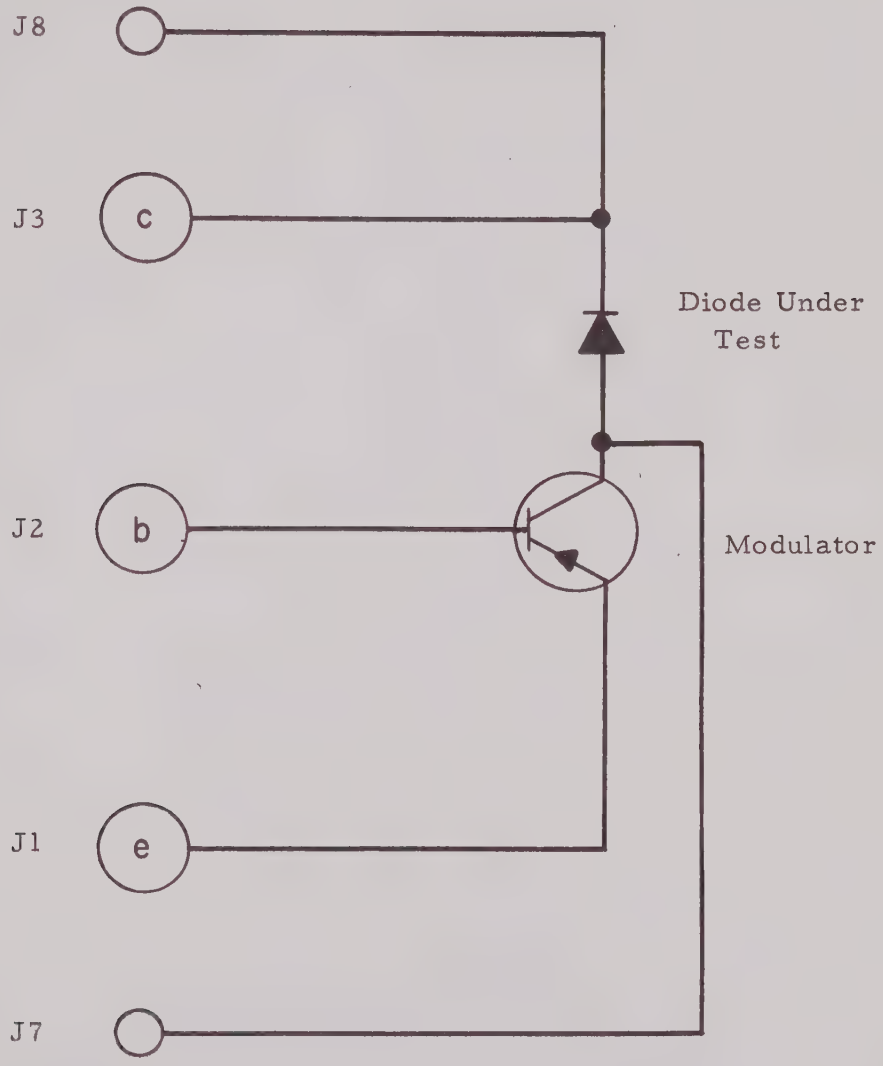
The basic test circuit for the diodes is derived as follows, and the basic NC-1 power transistor connections are made as shown:



In this mode of operation, the transistor current is a series of narrow pulses at 60 cps repetition. If a load were placed in the collector circuit, the combination of NC-1 and external transistor (called the modulator) could be used to supply pulse-load currents to any external load. In this type of operation the NC-1 and suitable external transistor have the properties of a pulse modulator.



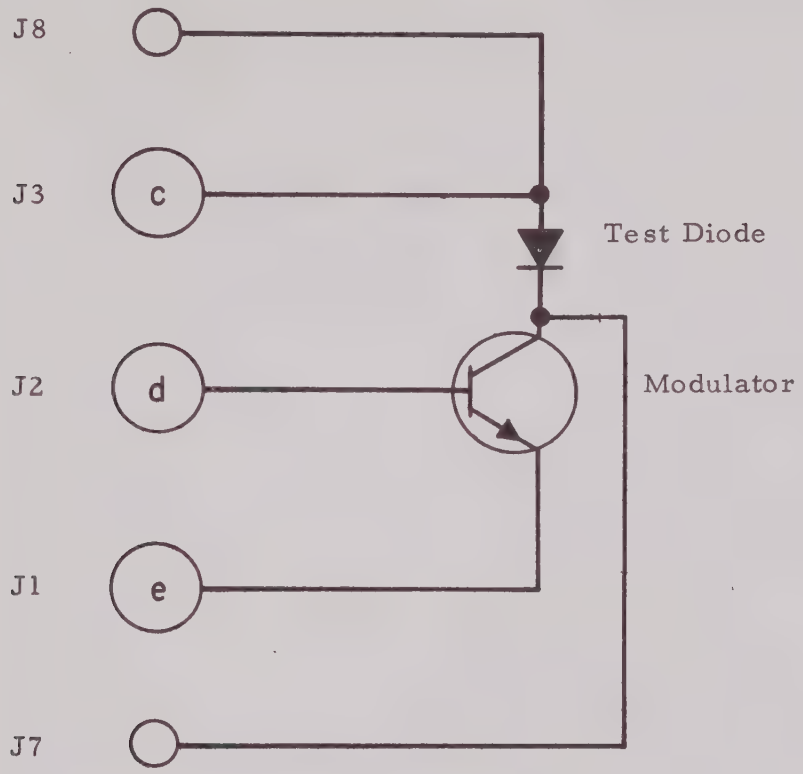
In particular, the external load can be diode operated in the forward direction as shown:



PNP Modulator

By using jacks J7 and J8 as the inputs of a peak-reading voltmeter, the peak forward-drop can be measured. The peak forward currents are measured on the usual collector ammeter since the modulator transistor and test diode have the same series current.

The connections for an NPN modulator are:



NPN Modulator

The requirements for the modulator transistor:

1. Either PNP or NPN may be used, Germanium or Silicon.
2. The modulator transistor should be able to handle the required peak current and supply voltage.
3. In order to keep modulator dissipation low, the whole collector supply appearing across modulator and load should be kept small; typically, 10 V is adequate.

4. Leakage current of the modulator should be kept as small as possible compared with the forward capability of the diode under test.

5. The full current capability of the NC-1 (up to 50 amperes) may be used.

A typical step-by-step procedure follows:

a. The modulator transistor and diode to be tested are connected as illustrated for PNP or NPN modulator as applicable.

b. The collector supply is set to the 10 volts V_{CO}-V_{EO} meter selector position.

c. The base drive control is adjusted for appropriate collector current in the modulator transistor and load (use lowest range possible to minimize leakage).

d. When the desired current is set, forward drop is read on the V_C scales (Connect sensing leads as illustrated for PNP or NPN modulator as applicable.)

NOTE

When forward pulse current is zero, the voltmeter may show a reading of a few tenths of a volt. This is caused by leakage current flowing through the modulator and diode load. When pulse current is applied, the voltmeter should rise and correctly peak detect maximum forward drop at peak current. This may be verified with an oscilloscope with a direct-coupled input.

The case size of many diodes is large enough so that no heat sink is required for these pulsed forward tests; however, each individual case should be investigated.

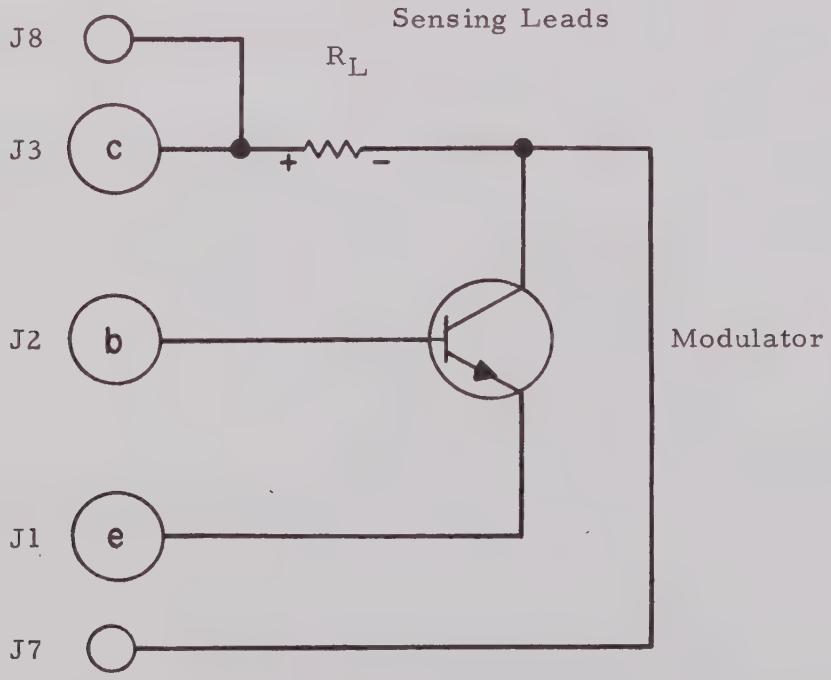
It is suggested that an oscilloscope be used to monitor the waveforms when tests are initially set up.

Pulsed Reverse Breakdown Tests

The NC-1 at present measures reverse diode characteristics by application of steady DC; in order to protect the device under test, current must be limited below breakdown.

Some manufacturers specify breakdown voltages by operating the device under test in a controlled breakdown condition. The usual condition is to inject a constant breakdown test current and observe that the junction voltage is above a certain minimum. As long as the device is operated from a current source, breakdown dissipation can be limited to a safe value, and the device will recover. In order to further limit device dissipation to a safe value, a pulse current source is often used.

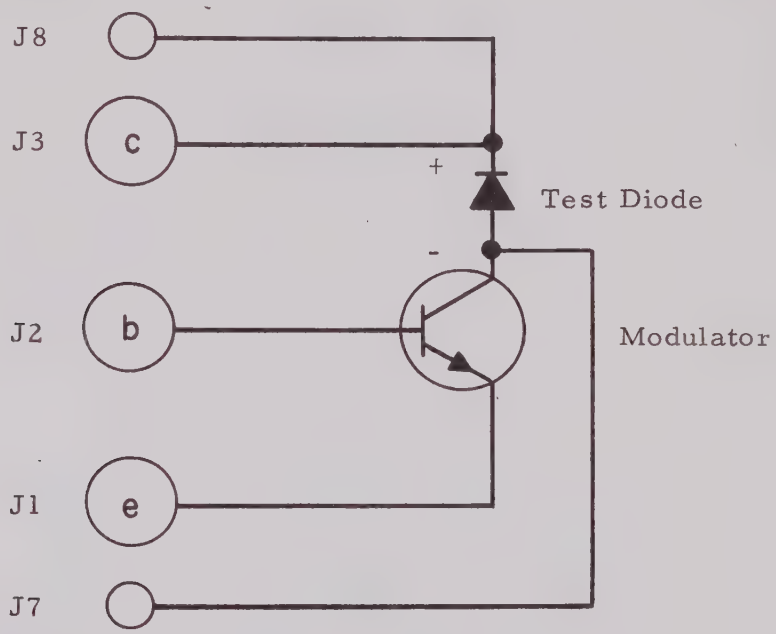
The basic NC-1, in conjunction with an external modulator transistor, is capable of making pulsed reverse breakdown tests. The basic circuit is as follows:



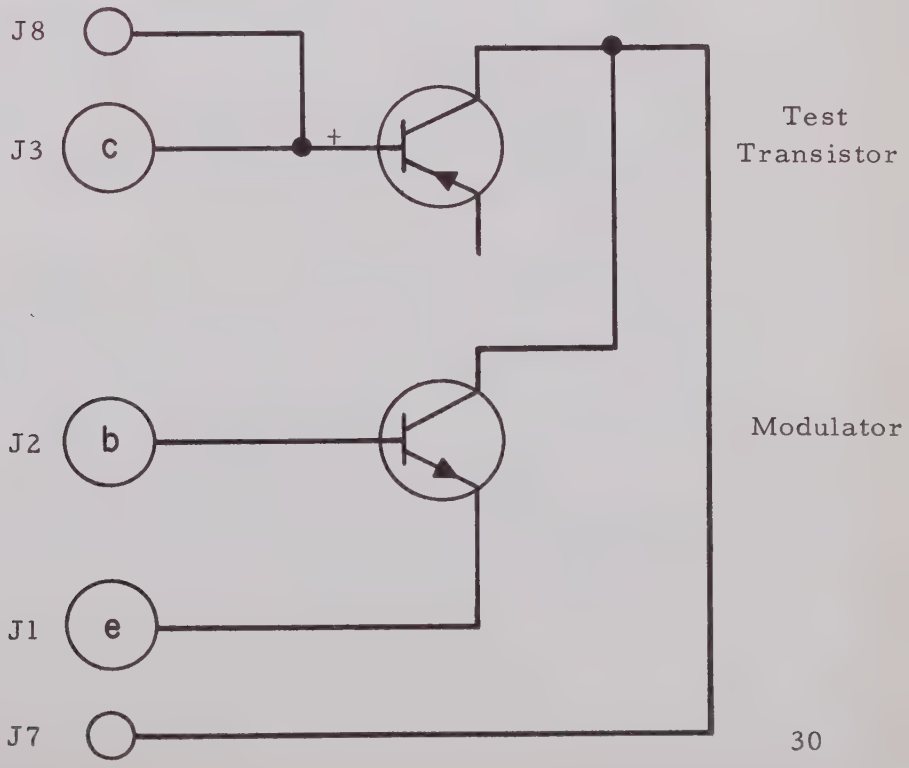
If collector supply and base drive are correctly adjusted, the combination of RL and modulator will act as a reasonable constant current generator.

Typically, if after the current is set R_L is shorted, the current will probably increase 10%. This indicates that the source impedance is about 10 times R_L, adequate for current uniting for this type of test. With R_L replaced by a test device, the circuit appears schematically.

a. Diode breakdown (BASIC)



b. Collector - Base Breakdown (PNP)



The basic rule for making connections can be deduced from the following chart:

Diode Symbol

Junction Structure

Bias Polarity for Reverse Tests

Selection of the supply voltage and modulator transistor are somewhat critical. Although the combination of NC-1 and modulator is primarily a current generator, it must have the capability of a large open-circuit output voltage to cause the device under test to break down. Hence, the current generator must be able to deliver an appreciable voltage to the load. The modulator transistor must be able to withstand the voltage across the load without breaking down. Therefore, it can be seen that this test setup requires a modulator whose breakdown is greater than the devices being tested. For safety's sake, reserve breakdown requirements on the modulator should be large.

Because of the reserve breakdown requirements, it is obvious that the NC-1 cannot test all transistors on the market. Fortunately, 100 to 150 volts will satisfy many of the transistors in use. Westinghouse series 1015D or 1016D will operate at 200V and are suitable as modulators for this application.

Because each manufacturer has different methods of specifying breakdown, any individual test requires close setting of a number of parameters,

open circuit voltage, etc. Hence, this procedure will not go into more detail. However, the basic circuit does work, and tests require this specialized need should be able to use the NC-1 for this application. The testing procedures of this bulletin apply to zener diodes, since they are devices with controlled reverse breakdown characteristics. A basic zener parameter is a variation of voltage with junction temperature. At present, zeners to be tested are soaked in an oil bath at the desired temperature. After the device temperature has stabilized, zener voltage is measured at a specified DC current. The power applied will heat the zener junction above the controlled oil bath temperature; the exact junction temperature is difficult to measure.

If the NC-1 is used with its low-duty cycle pulse, junction heating will be small, and junction temperature should remain substantially at an oil bath temperature during zener voltage tests. Hence, very accurate measurements of zener voltage vs junction temperature should be possible.

It is suggested that an oscilloscope be used to monitor the waveforms when tests are initially setup.

SECTION V

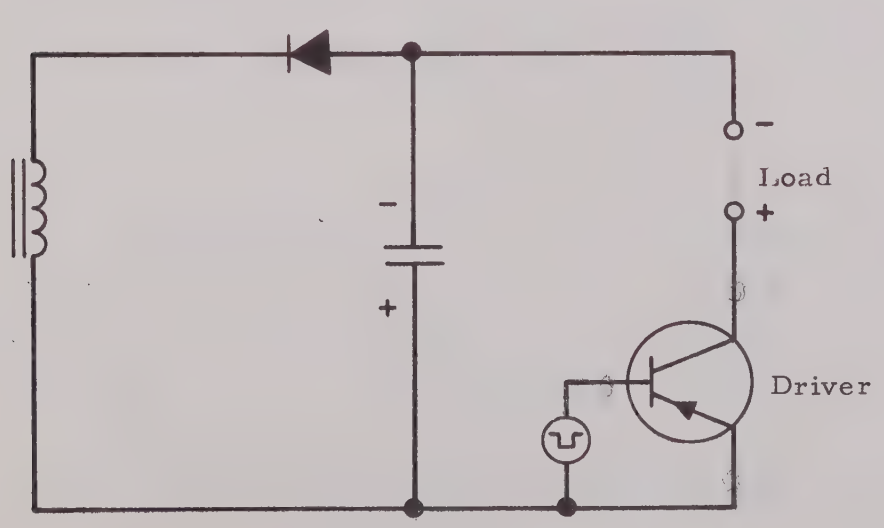
MAINTENANCE

All components in this instrument are conservatively rated and should provide a long, trouble-free life. No preventive maintenance is required. Critical selection of replacement tubes or transistors is not required.

It should be remembered there are numerous floating power supplies in the NC-1. For this reason the chassis should never be used as an electrical ground. Always connect test equipment ground leads to the appropriate return (ammeter common, voltmeter common, etc.). Keep in mind that these leads are not connected to the chassis ground.

Most of the circuits in this instrument are of straight forward operation, so no special troubleshooting procedures are given. The ammeter and voltmeter feedback amplifiers are designed with very high margins of stability, so that critical selection of replacement components is not required. A table of power supply voltages (which are not critical) and oscillograms of important waveforms are supplied as a guide to troubleshooting.

The base drive current generator is of the constant current type. A simplified schematic is shown as follows:



If any of the driver transistors should short (or develop a high impedance leak), it will not be possible to set I_B drive to zero. If the base-drive waveform shows a considerable amount of half sine ripple superimposed on rectangular drive, the drivers should be checked for shorts.

Accuracy Checks

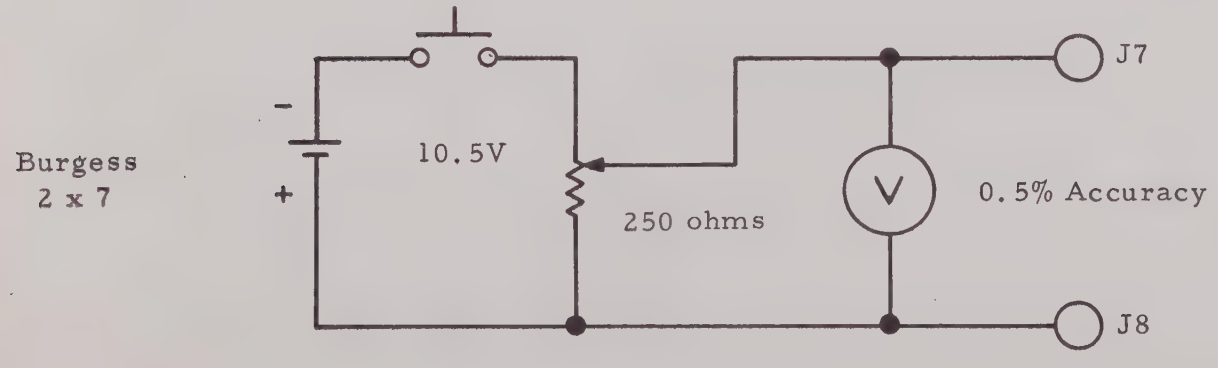
The basic measuring waveforms in the NC-1 are rectangular pulses that are amplified and peak detected for display on conventional DC meters. Accuracy tests have been devised to check the NC-1 circuits against an accurate conventional DC meter. These checks are listed as follows:

Voltmeter Accuracy

1. Set the function selector to PNP, the collector supply to the 15 volt range, and the voltmeter selector to V_C and the 10-volt metering range. Use a 500 μsec. pulse.
2. Remove the shorting wires between J1-J7 and J3-J8.
3. Connect an exact 10-volt DC source between J7 and J8 (positive to J7).
4. The NC-1 voltmeter should read 10 volts, plus or minus 3%.

NOTE

The source of test voltage should be absolutely ripple free. Suggested are a battery and a potentiometer, whose output is monitored by an external DC meter of 0.5% accuracy or better.



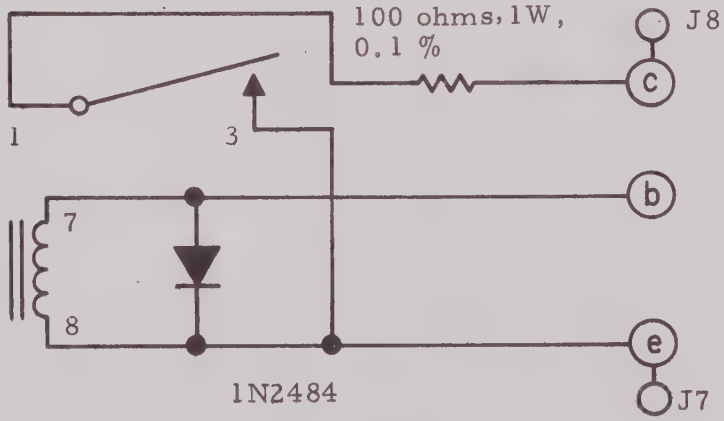
The NC-1 is factory calibrated by this procedure. The voltmeter gain is adjusted, if necessary, by padding R408. Once this value is factory set, it should seldom require readjustment.

Other ranges may be checked in a similar manner. Any check voltage should be absolutely ripple free (less than 0.1%) since the NC-1 reads peak, while the external standard reads average. For proper calibration, no ripple is allowable.

Ammeter Accuracy

The ammeter may be checked as follows:

1. Connect the following test jig to the NC-1.
2. Calibrate the voltmeter by the procedure just described. It is very important to note the meter readings that correspond to exactly 10.00 volts.



C. P. Clare
HGS 1012

3. Using the PNP polarity and 10 volt collector range, set controls as follows:
   a. Set ammeter to I_C, use 100 ma metering range.
   b. Set collector supply to exactly 10.00 volts.
   c. Set I_B range to 100 ma and set pulse width to 1000 μsec.

d. Slowly increase I_B drive control until relay is observed to operate following the base drive. (It will give an audible tone when operating.)

4. Check that pulse width in ammeter is 1000 μsec, plus or minus 50%, with 60 cps repetition. Check that phase control is set so I_C pulse occurs evenly centered about the AC power supply peak.

5. Under these conditions, the relay is simulating a perfect transistor. With a 10.00-volt supply and a 100-ohm resistor, the ammeter should indicate 100 milliamperes of current.

NOTE

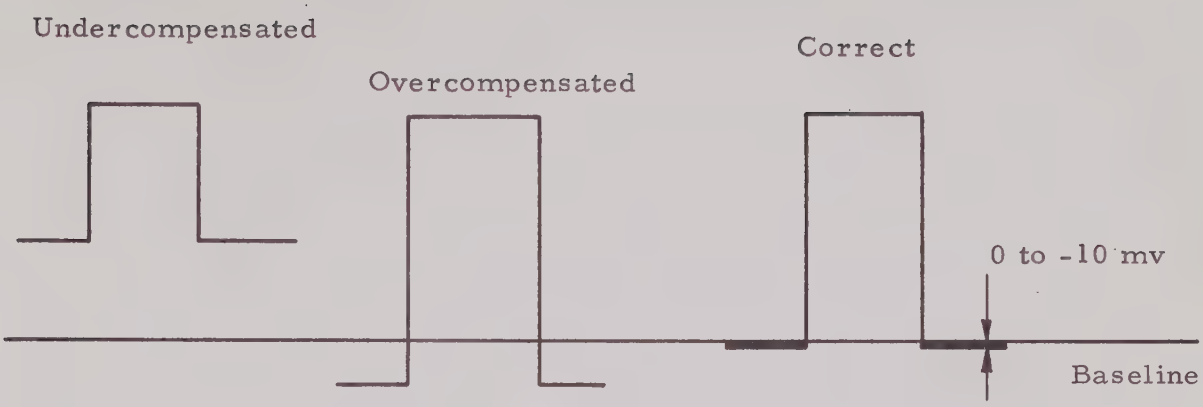
The ammeter is factory calibrated by padding R308. Once this value is factory set, it should seldom require readjustment. Other ranges use the same amplifier and meter movement, so they should be within the tolerance of the sampling resistor. Since these resistors are very heavy wire, they tend to be quite stable. Other ranges can be checked by using the appropriate values of calibrated collector supply and precision resistor.

Saturation Measurement Accuracy Checks (Low Voltage Supply Gate)

Transistor Q601 is used to sample the voltage across the test transistor which may be as low as 0.2 volt for some germanium power transistors in saturation. The saturation voltage of Q601 is cancelled by returning its emitter to a slightly negative voltage. This value of negative voltage is trimmed out for each instrument by factory installing a padding resistor across R626. If transistor 2N337 is replaced, this saturation offset cancellation should be re-checked as follows:

1. Set the collector supply to 3 volts.

2. Observe the signal at the collector of Q601 with a fairly sensitive oscilloscope (100 mv/cm). The signal should be as follows:



3. Replace padding resistor with correct value.

NOTE

On final adjustment, pulse base line should be within 0 to minus 10 mv of voltmeter common.

4. As a final check on saturation accuracy, a transistor known to be satisfactory may be checked by using well-filtered DC supplies and accurate conventional meters. Results should be reproducible on the NC-1.

Pulse Width Adjustment

1. Connect the ground circuit of an oscilloscope to the base common lead.
2. Connect the signal lead to the collector of Q210. There should be negative 5V gates at a 60 cps repetition rate.
3. Set the I_B PULSE selector to 1000 μsec pulse.
4. Adjust the control R221 for a 1000 μsec pulse.

Phase Shift Adjustment

1. Set the NPN-PNP switch to NPN.
2. Connect a 10-ohm, 1/2-watt resistor between J1 and J2.

3. Connect the ground terminal of a dual beam oscilloscope J1 and synchronize scope to 60 cycles.

4. Adjust the base controls so that 5-volt peak rectangular pulses are obtained on one signal trace.

5. Connect the other signal lead to the junction of leads X2 and X3 of T106.

6. Put V_C Supply RANGE switch S102 to the 0 - 15 volt position.

7. Adjust T107 to approximately half-scale.

8. After pattern is synchronized, adjust sweep length so that one 500 μsec pulse takes up an appreciable portion of the sweep.

9. Adjust phase control R102 so that the 500 μsec gate is centered evenly about the peak of the AC sine wave as shown below.

Power Supply Voltages

Power supply voltages have wide tolerances. The following table lists normal tolerances that will permit proper operation; all were obtained with 117-volt input.

(a)	Ammeter	+300 v supply	285 ± v.
	Ammeter	-150 v supply	-150 ± 25 v.
(b)	Voltmeter	+300 v supply	285 ± 25 v.
	Voltmeter	-150 v supply	-150 ± 25 v.
	Voltmeter	-300 v supply	-350 ± 25 v.
(c)	Base	+ 9 v supply	9 ± 1 v.
	Base	- 9 v supply	-7.5 ± 0.5 v.
	Base	-1.5 v supply	1.4 ± 0.2 v.
(d)	Overload	-9 v supply	-6 ± 0.5 v, relay operated.
	Overload	-8 v supply	-5.9 ± 0.5 v, relay operated.

Waveforms

Key waveforms are given in Appendix B.

SECTION VI

MODEL NC-1 PARTS LIST

Schematic Designation	Description	B/A Designation
C101	2μf, 200V, tubular mylar (Goodall)	CP-205-2
C102	25μf, 25V, tubular electrolytic	CE-256-1
C103	100μf, 25V, tubular electrolytic	CE-107-2
C104	25μf, 25V, tubular electrolytic	CE-256-1
C105	1000μf, 15V, tubular electrolytic	CE-108-4
C106	25μf, 25V, tubular electrolytic	CE-256-1
C107	20/20/20/20μf, 450V, electrolytic	CE-206-4
C108	20/20/20/20μf, 450V, electrolytic	CE-206-4
C109	20μf, 450V, tubular electrolytic	CE-206-8
C110	20μf, 450V, tubular electrolytic	CE-206-8
C111	20μf, 450V, tubular electrolytic	CE-206-8
C112	25μf, 25V, tubular electrolytic	CE-256-1
C113	20μf, 450V, tubular electrolytic	CE-206-8
C114	20μf, 450V, tubular electrolytic	CE-206-8
C115	150μf, 350V, twistprong electrolytic	CE-157-2
C116	150μf, 350V, twistprong electrolytic	CE-157-2
C117	4000μf, 50V, electrolytic (Cornell-Dubilier) FB5040	CE-408-1
C118	500μf, 25V, tubular electrolytic	CE-507-2
C201	3000μμf, 500V, 5%,mica	CM-302-1
C202	1500μμf, 500V, 5%, mica	CM-152-1
C203	6200μμf, 500V, 5%, mica	CM-622-1
C204	6200μμf, 500V, 5%, mica	CM-622-1
C205	.22μf, 200V, tubular mylar (Goodall)	CP-224-3
C206	.22μf, 200V, tubular mylar (Goodall)	CP-224-3
C207	.0047μf, 600V, tubular mylar (Goodall)	CP-472-1
C208	.001μ, Ceramic	CC-102-1
C209	25μf, 25V, electrolytic tubular	CE-256-1
C210	25μf, 25V, electrolytic tubular	CE-256-1
C211	25μf, 25V, electrolytic tubular	CE-256-1
C301	40/40/40/40 μf, 450V, electrolytic	CE-206-4
C302	.002μf, 600V, tubular mylar (Goodall)	CP-202-2
C303	.1μf, 600V, tubular mylar (Goodall)	CP-104-11
C304	1μf, 200V, tubular mylar (Goodall)	CP-105-3
C305	.22μf, 200V, tubular mylar (Goodall)	CP-224-3
C306	20μf, 450V, electrolytic	CE-206-3

PARTS LIST (continued)

Schematic Designation	Description	B/A Designation
C401	Not Used	
C402	.068μf, 600V, mylar tubular (Goodall)	CP-683-1
C403	.0047μf, 600V, mylar tubular (Goodall)	CP-472-1
C404	20μf, 450V, electrolytic	CE-206-3
C405	.068μf, 600V, mylar tubular (Goodall)	CP-683-1
C406	.47μf, 200V, mylar tubular (Goodall)	CP-474-1
C601	25μf, 25V, tubular electrolytic	CE-256-1
C602	.1μf, 200V, tubular mylar (Goodall)	CP-104-10
C603	.068μf, 600V, tubular mylar (Goodall)	CP-683-1
C604	200 μμf, 500V, 20%, mica	CM-201-1
C605	20μf, 450V, tubular electrolytic	CE-206-8
C606	450μf, 3V, electrolytic	08234
C607	150μμf, 500V, 20%, mica	CM-151-1
C608	47μμf, 500V, 20% mica	CM-470-1
C609	22μμf, 500V, 20% mica	CM-220-1
C610	150μμf, 500V, 20%, mica	CM-151-1
C611	47μμf, 500V, 20%, mica	CM-470-1
C612	22μμf, 500V, 20%, mica	CM-220-1
C613	10μμf, 500V, 20%, mica	CM-100-2
C614	5μμf, 500V, 20%, mica	CM-050-11
C701	.01μf, 600V, ceramic disc	CC-103-1
CR101	1N2482 silicon rectifier (Sarkes-Tarzian F-2)	CR-55
CR102	1N2482 silicon rectifier (Sarkes-Tarzian F-2)	CR-55
CR103	1N2482 silicon rectifier (Sarkes-Tarzian F-2)	CR-55
CR104	1N2484 silicon rectifier (Sarkes-Tarzian F-6)	CR-54
CR105	1N2484 silicon rectifier (Sarkes-Tarzian F-6)	CR-54
CR106	1N2484 silicon rectifier (Sarkes-Tarzian F-6)	CR-54
CR107	1N2484 silicon rectifier (Sarkes-Tarzian F-6)	CR-54
CR108	Silicon rectifier (Sarkes-Tarzian 30T3N)	CR-66
CR109	Not Used.	
CR110	1N1160 silicon rectifier (Sarkes-Tarzian 30RAN)	CR-52
CR111	1N1124 silicon rectifier (Texas Instruments)	CR-51
CR112	1N2482 silicon rectifier, (Sarkes-Tarzian F-2)	CR-55
CR113	1N2482 silicon rectifier (Sarkes-Tarzian F-2)	CR-55
CR201	Diode, crystal, (Transitron S151G)	CR-18
CR202	Diode, crystal, (Transitron S151G)	CR-18
CR203	Diode, crystal, (Transitron S151G)	CR-18

PARTS LIST (continued)

Schematic Designation	Description	B/A Designation
CR204	Diode, crystal, (Transitron S151G)	CR-18
CR205	1N2482, silicon rectifier (Sarkes-Tarzian F-2)	CR-55
CR206	Diode, crystal, (Transitron S151G)	CR-18
CR207	1N2484, (Sarkes-Tarzian F-6)	CR-54
CR208	1N2484, (Sarkes-Tarzian F-6)	CR-54
CR209	1N2484, (Sarkes-Tarzian F-6)	CR-54
CR210	1N2484, (Sarkes-Tarzian F-6)	CR-54
CR401	Diode 1N281 (Raytheon)	CR-68
CR402	Diode 1N281 (Raytheon)	CR-68
CR403	Diode, crystal 1N281	CR-68
CR601	1N2484 (Sarkes-Tarzian F-6)	CR-54
DS101	Lamp, NE-51	LA-8
DS102	Lamp, NE-51	LA-8
F101	3A, Slo-Blo (in FH-11 fuseholder)	FS-8
F102	2A, Slo-Blo (in FH-11 fuseholder)	FS-14
F201	2A, (in FH-11 fuseholder)	20752
J1	Binding post, yellow	TR-163
J2	Binding post, green	TR-162
J3	Binding post, blue	TR-161
J4	Binding post, yellow	TR-164
J5	Binding post, green	TR-174
J6	Socket, transistor	SO-53
J7	Binding post, yellow	TR-164
J8	Binding post, blue	TR-153
J9	Jack, Telephone Type, Switchcraft 13B	JK-105
K201	Relay, 2PDT (Potter-Brumfield)6V DC coil	RE-37
M501	Ammeter, 50μA, 2% (Specify with dial plate B-NC-1-103)	MT-33
M601	Voltmeter, 50μA, 2% (Specify with dial plate B-NC-1-105	MT-33
Q201	Transistor, 2N651, (Motorola)	2N651
Q202	Transistor, 2N651, (Motorola)	2N651
Q203	Transistor, 2N376A, (Motorola)	2N376A
Q204	Transistor, 2N376A, (Motorola)	2N376A
Q205	Transistor, 2N376A, (Motorola)	2N376A
Q206	Transistor, 2N654, (Motorola)	2N654
Q207	Transistor, 2N654, (Motorola)	2N654

PARTS LIST (continued)

Schematic Designation	Description	B/A Designation
Q208	Transistor, 2N654, (Motorola)	2N654
Q209	Transistor, 2N654, (Motorola)	2N654
Q210	Transistor, 2N654, (Motorola)	2N654
Q211	Transistor, 2N654, (Motorola)	2N654
Q212	Transistor, 2N654, (Motorola)	2N654
Q213	Transistor, 2N654, (Motorola)	2N654
Q214	Transistor, 2N376A, (Motorola)	2N376A
Q601	Transistor, 2N377	2N377
R101	100K, 1/2W, 5%, comp.	RCE-104J
R102	10K pot, 2W, comp.	RV-103-10
R103	100 ohms, 1/2W, 5%, comp.	RCE-101J
R104	1 ohm, 3W, wirewound, 10%	RW-010-6
R105	22 ohms, 1/2W, 5%, comp.	RCE-220J
R106	7K, 5W, wirewound	RW-702-1
R107	68K, 2W, 5%, comp.	RCH-683J
R108	68K, 2W, 5%, comp.	RCH-683J
R109	10K, 5W, wirewound	RW-103-5
R110	220 ohms, 1/2W, 5%, comp.	RCE-221J
R111	220 ohms, 1/2W, 5%, comp.	RCE-221J
R112	47K, 2W, 5%, comp.	RCH-473-J
R113	47K, 2W, 5%, comp.	RCH-473-J
R114	100K, 1/2W, 5%, comp.	RCE-104J
R115	6K, 20W, wirewound, 10%	RW-602-3
R116	500 ohms, 20W, wirewound, 10%	RW-501-3
R117	150K, 2W, 5%, comp.	RCH-154J
R118	100K, 2W, 5%, comp.	RCH-104J
R119	150K, 2W, 5%, comp.	RCH-154J
R120	100K, 2W, 5%, comp.	RCH-104J
R121	10K, 1/2W, 5%, comp.	RCE-103J
R122	4.7K, 1/2W, comp.	RCE-472-J
R123	1K, 1/2W, comp.	RCE-102-J
R201	910 ohm, 1/2W, 5%, comp.	RCE-911-J
R202	250 ohm pot, 2W, 10%, comp.	20594
R203	150 ohm, 1/2W, 5%, comp.	RCE-151-J
R204	150 ohm, 1/2W, 5%, comp.	RCE-151-J
R205	100 ohm, 1/2W, 5%, comp.	RCE-101-J
R206	33 ohm, 1/2W, 5%, comp.	RCE-330-J
R207	Not Used.	
R208	68K, 1/2W, 5%, comp.	RCE-683J
R209	3.3K, 1/2W, 5%, comp.	RCE-332J
R210	3.3K, 1/2W, 5%, comp.	RCE-332J

PARTS LIST (continued)

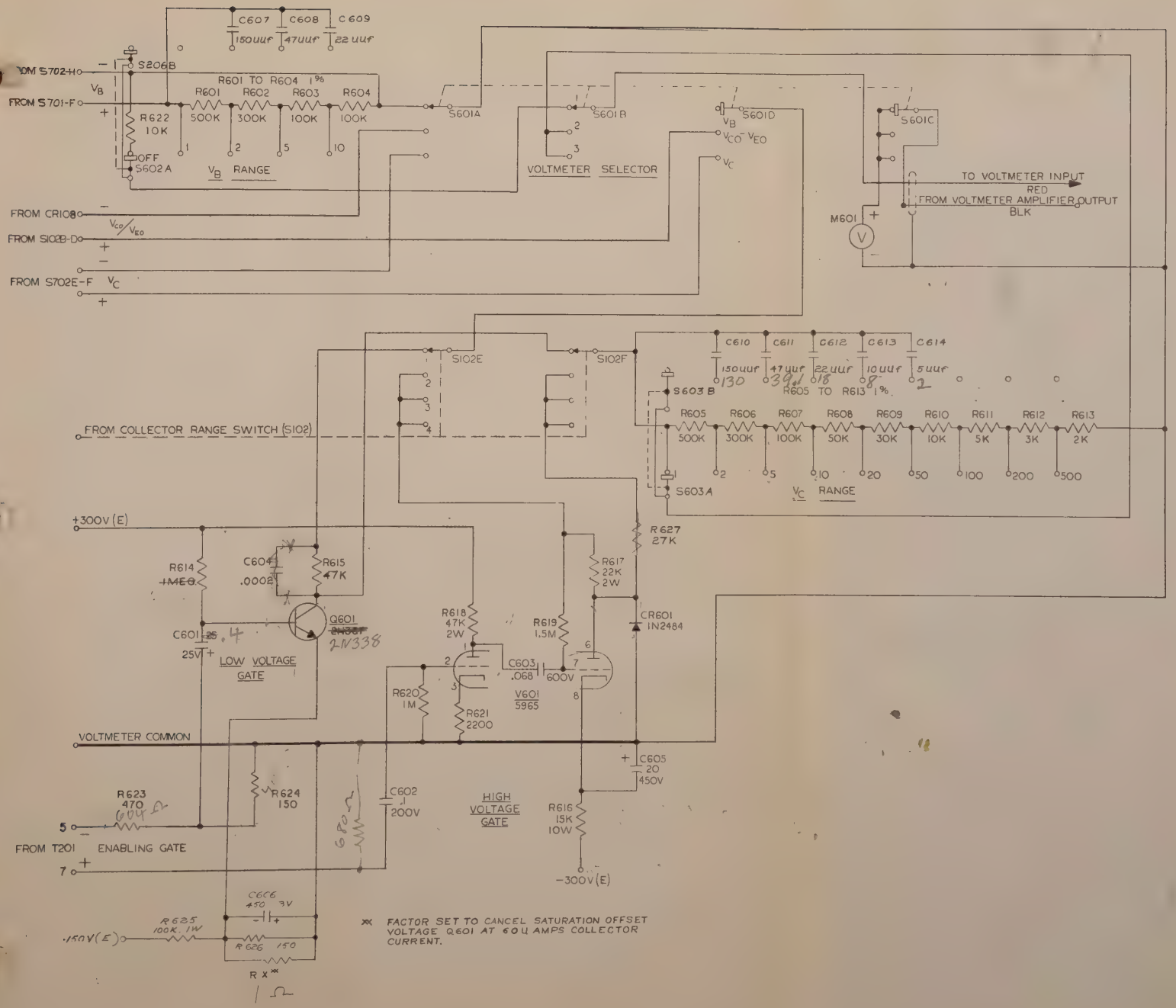
Schematic Designation	Description	B/A Designation
R211	8.2K, 1/2W, 5%, comp.	RCE-822J
R212	2.2K, 1/2W, 5%, comp.	RCE-222J
R213	2.2K, 1/2W, 5%, comp.	RCE-222J
R214	91K, 1/2W, 5%, comp.	RCE-913J
R215	6.2K, 1/2W, 5%, comp.	RCE-622J
R216	1K, 1/2W, 5%, comp.	RCE-102J
R217	4.7K, 1/2W, 5%, comp.	RCE-472J
R218	10K, 1/2W, 5%, comp.	RCE-103J
R219	20K, 1/2W, 5%, comp.	RCE-203J
R220	100K, 1/2W, 5%, comp.	RCE-104J
R221	25K, pot, 2W, comp.	RV-253-3
R222	1K, 1/2W, 5%, comp.	RCE-102J
R223	100 ohms, 1/2W, 5%, comp.	RCE-101J
R224	3.3K, 1/2W, 5%, comp.	RCE-332J
R225	10 ohms, 1/2W, 5%, comp.	RCE-100J
R226	2.2K, 1/2W, 5%, comp.	RCE-222J
R227	2.2K, 1/2W, 5%, comp.	RCE-222J
R228	1K, 1/2W, 5%, comp.	RCE-102J
R229	220 ohms, 1/2W, 5%, comp.	RCE-221J
R230	680 ohm, 1/2W, 5%, comp.	RCE-681-J
R231	180 ohm, 1/2W, 5%, comp.	RCE-181-J
R232	270 ohm, 1/2W, 5%, comp.	RCE-271-J
R233	33 ohms, 1/2W, 5%, comp.	RCE-330J
R234	0.1 ohm, 5W, 10%, wirewound	08233
R235	0.1 ohm, 5W, 10%, wirewound	08233
R236	10 ohm, 1/2W, 5%, comp.	RCE-100J
R237	10 ohm, 1/2W, 5%, comp.	RCE-100J
R238	1.0 ohm, 5W, 10%, wirewound	RW-010-2
R239	10 ohm, 1W, comp., 5%	RCG-100J
R240	3.3K, 1/2W, 5%, comp.	RCE-332J
R241	220 ohm, 1/2W, 5%, comp.	RCE-221-J
R242	47K, 1/2W, 5%, comp.	RCE-473J
R243	10K, 1/2W, 5%, comp.	RCE-103J
R244	68 ohm, 1/2W, 5%, comp.	RCE-600-J
R245	15 ohm, 2W, 5%, comp.	RCH-150-J
R301	4.7K, 1/2W, 5%, comp.	RCE-472J
R302	4.7K, 1/2W, 5%, comp.	RCE-472J
R303	4.7K, 1/2W, 5%, comp.	RCE-472J
R304	4.7K, 1/2W, 5%, comp.	RCE-472J
R305	100K, 1W, 5%, comp.	RCG-104J
R306	100K, 1W, 5%, comp.	RCG-104J

PARTS LIST (continued)

Schematic Designation	Description	B/A Designation
R307	10K, 2W, 5%, comp.	RCH-103J
R308	10K, 1/2W, 1/2%, film	RF-103-5
R309	1 Meg., 1/2W, 5%, comp.	RCE-105J
R310	1 Meg., 1/2W, 5%, comp.	RCE-105J
R311	1 Meg., 1/2W, 5%, comp.	RCE-105J
R312	47K, 2W, 5%, comp.	RCH-473J
R313	1 Meg., 1/2W, 5%, comp.	RCE-105J
R314	5 Meg., 1/2W, 1%, film	RF-505-5
R315	1 Meg., 1/2W, 5%, comp.	RCE-105J
R316	960K, 1/2W, 1/2%, film	RF-964-1
R317	10K, 1/2W, 5%, comp.	RCE-103J
R318	150K, 1/2W, 5%, comp.	RCE-154J
R319	1K, 1/2W, 5%, comp.	RCE-102J
R401	4.7K, 1/2W, 5%, comp.	RCE-472J
R402	100K, 1W, 5%, comp.	RCG-104J
R403	100K, 1W, 5%, comp.	RCG-104J
R404	100K, 1W, 5%, comp.	RCG-104J
R405	4.7K, 1/2W, 5%, comp.	RCE-472J
R406	5K, 1/2W, 1/2%, film	RF-502-4
R407	1M, 1/2W, 5%, comp.	RCE-105J
R408	100K, 1/2W, 1/2%, film	RF-104-6
R409	1M, 1/2W, 5%, comp.	RCE-105J
R410	47K, 2W, 5%, comp.	RCH-473J
R411	4.7K, 1/2W, 5%, comp.	RCE-472J
R412	56K, 2W, 5%, comp.	RCH-563J
R413	1M, 1/2W, 5%, comp.	RCE-105J
R414	374K, 1/2W, 1/2%, comp.	RF-374-1
R501	10 ohms, 1/2W, 5%, comp.	RCE-100J
R502 A&B	.8 ohms total (tapped), wirewound, 1%	RW-008-2
R503 A-G	.2 ohms total (tapped), 1%, wirewound	RW-002-1
R504	10K, 1/2W, 1%, carbon film	RF-103-3
R505	3330 ohms, 1/2W, 1%, carbon film	RF-332-2
R506	1110 ohms, 1/2W, 1%, carbon film	RF-112-1
R507	527 ohms, 1/2W, 1%, carbon film	RF-521-1
R508	256 ohms, 1/2W, 1%, carbon film	RF-251-3
R509	100 ohms, 1/2W, 1%, carbon film	RF-101-3
R510	50 ohms, 1/2W, 1%, carbon film	RF-500-4

PARTS LIST (continued)

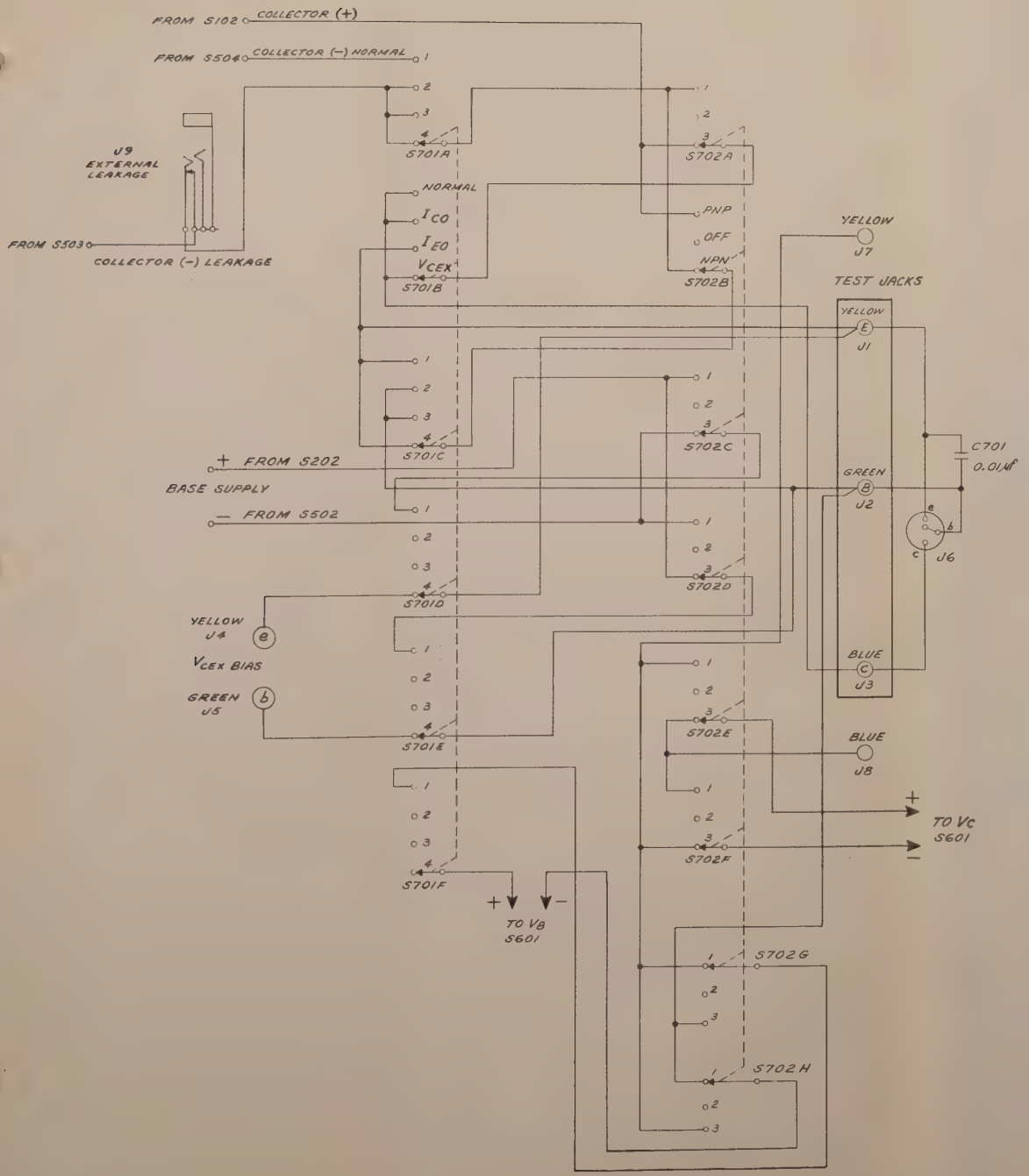
Schematic Designation	Description	B/A Designation
R511	25 ohms, 1/2W, 1%, carbon film	RF-250-1
R512	10 ohms, 1/2W, 1%, carbon film	RF-100-2
R513	5 ohms, 1/2W, 1%, carbon film	RF-050-1
R514	8K, 1/2W, 1%, carbon film	RF-802-1
R515	50 ohms, 1/2W, 1%, film	RF-500-4
R516	30 ohms, 1/2W, 1%, film	RF-300-2
R517	10 ohms, 1/2W, 1%, film	RF-100-2
R518	5 ohms, 1/2W, 1%, film	RF-050-1
R519	3 ohms, 1/2W, 1%, film	RF-030-1
R520	1 ohm, 1/2W, 1%, wirewound	RW-010-5
R521 A&B	.8 ohms total (tapped), 1/2W, 1%, wirewound	RW-008-2
R522 A&B	.015 ohms total (tapped), 1/2W, 1%, wirewound	RW-001-4
R523 A&B	.05 ohms total (tapped), 1/2W, 1%, wirewound	RW-001-5
R524	10 ohms, 1/2W, 5%, comp.	RCE-100J
R601	500K, 1/2W, 1%, film	RF-504-1
R602	300K, 1/2W, 1%, film	RF-304-3
R603	100K, 1/2W, 1%, film	RF-104-5
R604	100K, 1/2W, 1%, film	RF-104-5
R605	500K, 1/2W, 1%, film	RF-504-1
R606	300K, 1/2W, 1%, film	RF-304-3
R607	100K, 1/2W, 1%, film	RF-104-5
R608	50K, 1/2W, 1%, film	RF-503-3
R609	30K, 1/2W, 1%, film	RF-303-1
R610	10K, 1/2W, 1%, film	RF-103-3
R611	5K, 1/2W, 1%, film	RF-502-2
R612	3K, 1/2W, 1%, film	RF-302-2
R613	2K, 1/2W, 1%, film	RF-202-3
R614	1 Meg, 1/2W, 5%, comp.	RCE-105-J
R615	47K, 1/2W, 5%, comp.	RCE-473-J
R616	15K, 10W, 10%, wirewound	RW-153-3
R617	22K, 2W, 5%, comp.	RCH-223J
R618	47K, 2W, 5%, comp.	RCH-473J
R619	1.5 Meg., 1/2W, 5%, comp.	RCE-155J
R620	1 Meg., 1/2W, 5%, comp.	RCE-105J
R621	2.2K, 1/2W, 5%, comp.	RCE-222J
R622	10K, 1/2W, 5%, comp.	RCE-103J
R623	680 ohms, 1/2W, 5%, comp.	RCE-681J
R625	100K, 1W, 5%, comp.	RCG-104-J
R626	150 ohm, 1/2W, 5%, comp.	RCE-151-J
R627	27K, 1/2W, 5%, comp.	RCE-273-J



** FACTOR SET TO CANCEL SATURATION OFFSET VOLTAGE Q601 AT 60 µ AMPS COLLECTOR CURRENT.

NC 1-119 E

NOTE
1. UNLESS OTHERWISE NOTED ALL RESISTOR VALUES IN OHMS, 1/2W ±5%
2. UNLESS OTHERWISE NOTED ALL CAPACITOR VALUES IN MICROFARADS



NOTE:
FOR USE OF J7 & J8 SEE INSTRUCTION MANUAL.

NCI-120 E

FUNCTION & NPN-PNP SWITCH SCHEMATIC

NC-1 APPLICATION BULLETIN #3

Field Modification of Serial 101 - 120

Several worthwhile customer suggestions about improving NC-1 operation have been adopted. All units with serial No. 121 and above will differ from the earlier units in three ways:

1) External leakage current jack on rear panel.

2) Four ranges of base drive; a low range of 0-10 MA has been provided to secure good control at very low base currents.

3) Improvements to the collector voltmeter for making more accurate saturation measurements at high currents, 10 amps and above.

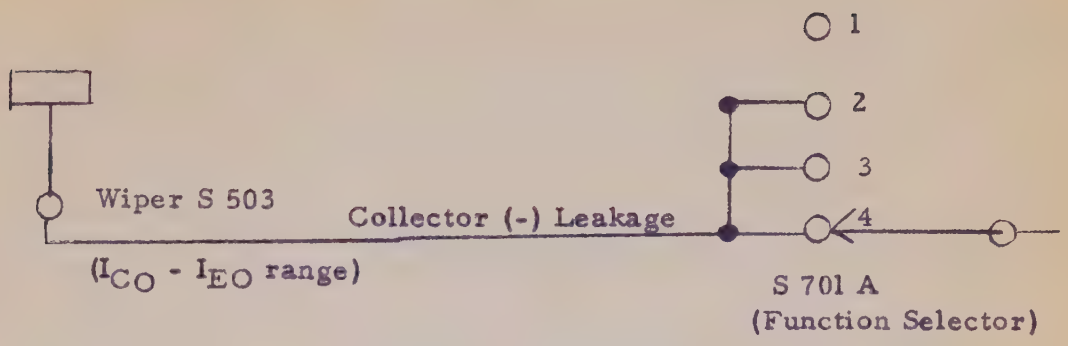
This bulletin will give detailed field modification instructions so that the earlier NC-1's may be upgraded to give maximum performance.

1) External Leakage Current Jack

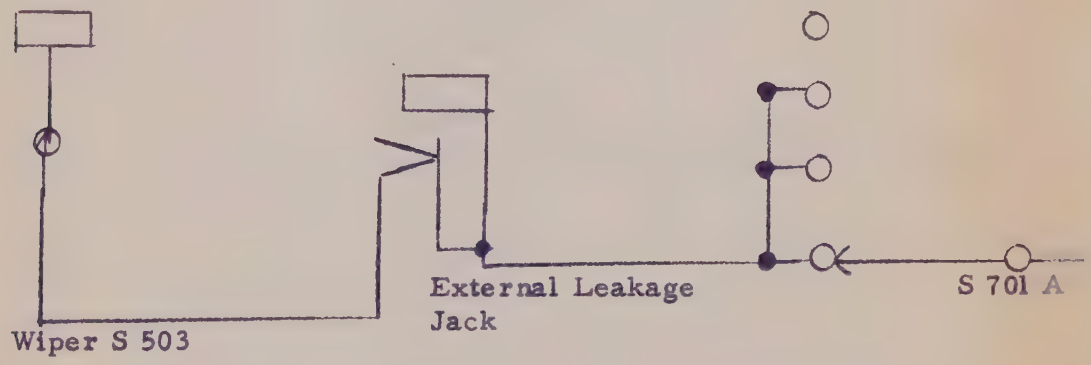
The lowest leakage current range on the NC-1 is presently 50 microamperes full scale; accurate readings down to 5 microamps are possible. For those who want to measure at lower levels, a rear panel jack has been added for plugging in an external meter. The external meter is connected in series with the existing leakage current meter.

The jack is added as follows: suggested mounting location is on the rear panel, centered between the fuses and the base pulse adjusting pots. The jack should be a Switchcraft #13B or equivalent; it should be insulated from the chassis with suitable shoulder washers.

Present electrical connections are as follows:



The jack should be wired as follows:

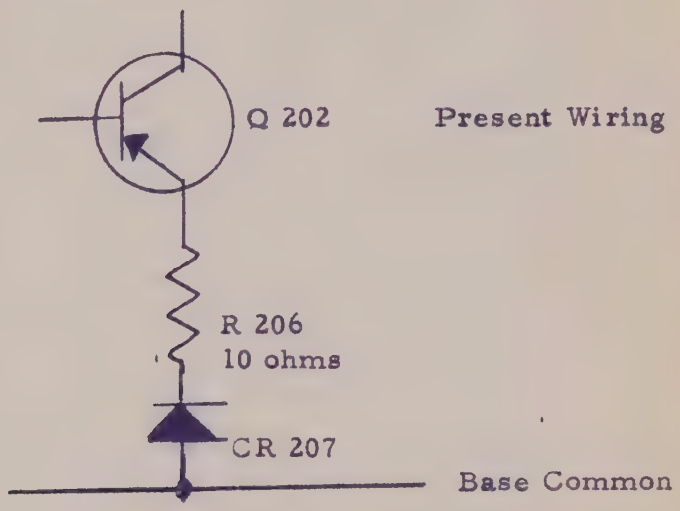


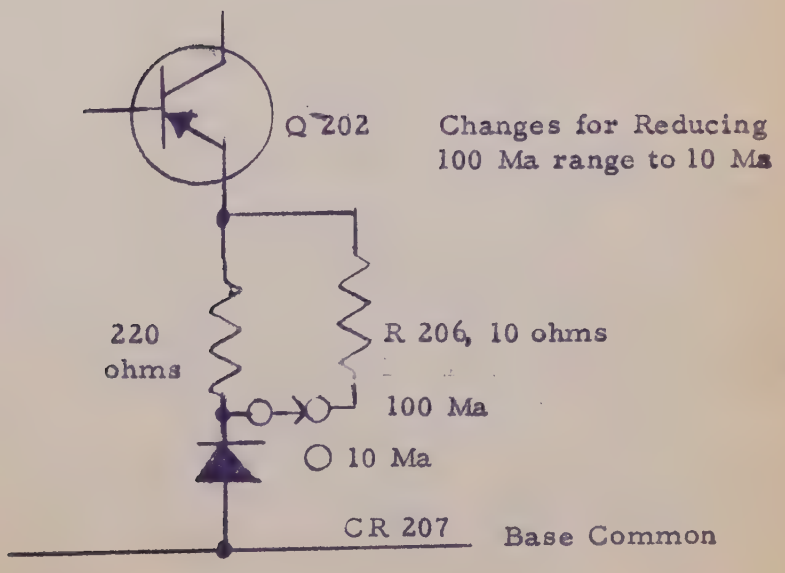
2) Base Drive 0-10 MA Range

A 0-10 MA base drive range is desirable for good control at low base currents. The ideal solution involves replacing S 202 with a 4-position unit (present switch is 3-positions). This change is best described on a marked-up schematic and we will be very happy to provide one to any cus-

tomer who desires it.

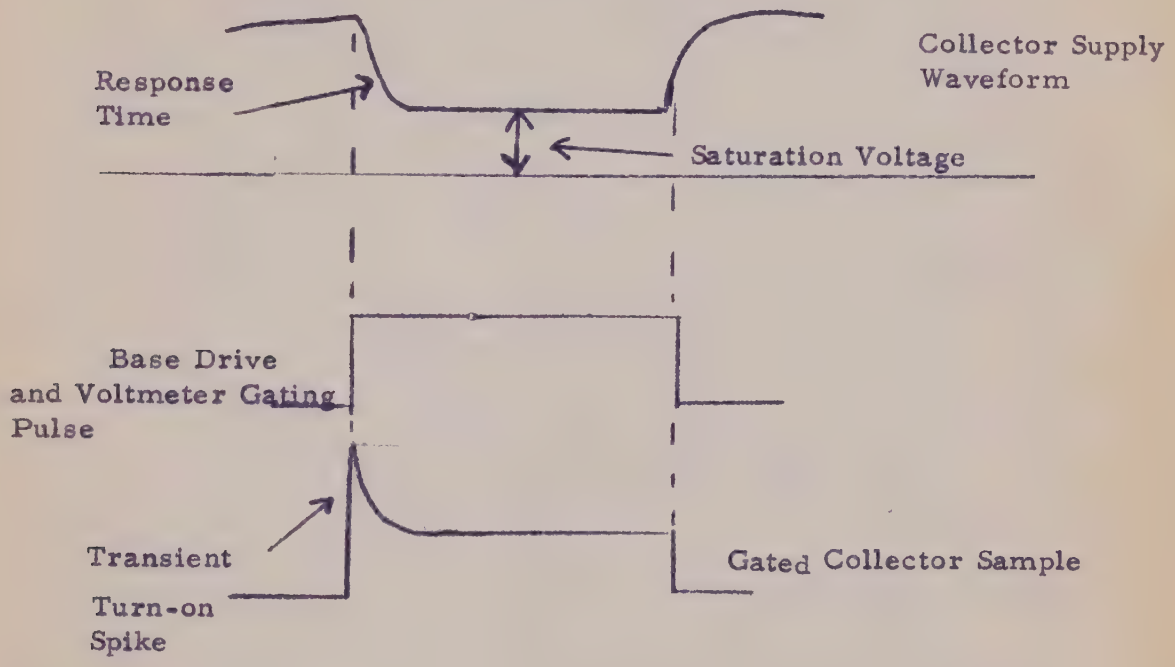
A simpler change which many customers will find satisfactory is to add a toggle switch on the rear panel that will convert the 0-100 MA range to two ranges, a reduced span of 0-10 MA or the full 0-100 MA. Schematic details are as follows:





3) Saturation Measurements

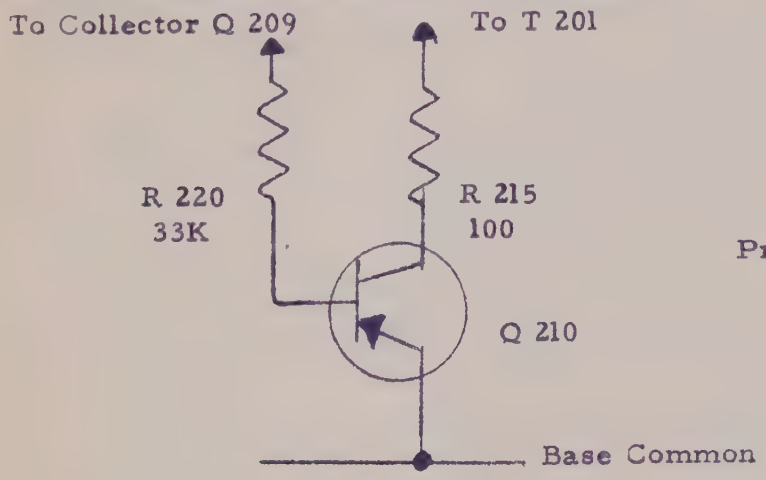
On very high current, slow speed transistors, the older NC-1's will read too high a saturation voltage. The high saturation voltage arises from a sampling error in the NC-1 collector voltmeter. The origin of the error can be seen from the following timing diagram.



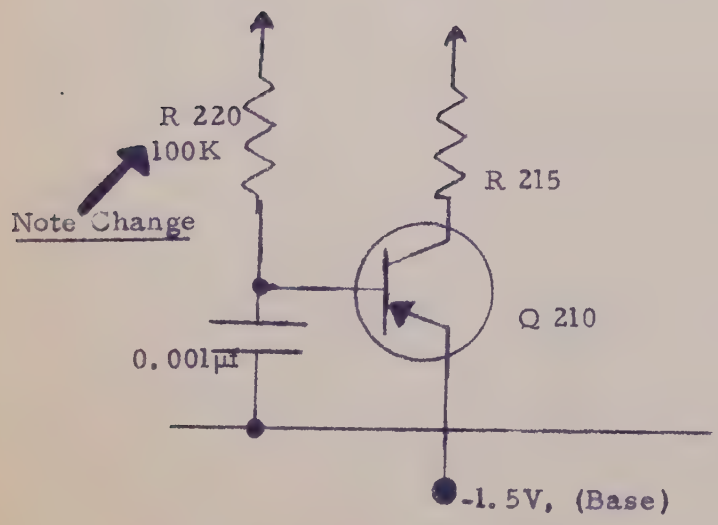
The collector sampling voltmeter is gated open by the base drive pulse. The collector current may lag the base current due to the test transistors' response time so that the gated collector sample may have a large transient spike on the leading edge, representing the voltage across the transistor during switching on. This type of error can be identified by observing the signal between the collector of Q 601 and voltmeter common, normal operation should

show clean rectangular pulses free of overshort on the leading edge.

The solution to this problem is to delay the sample pulse by 20 μ sec from the base pulse, allowing the test transistor to reach final collector current before sampling voltage. This is accomplished by an RC delay circuit as follows. There are adequate spare terminals on the wiring boards to accomodate the few extra components.

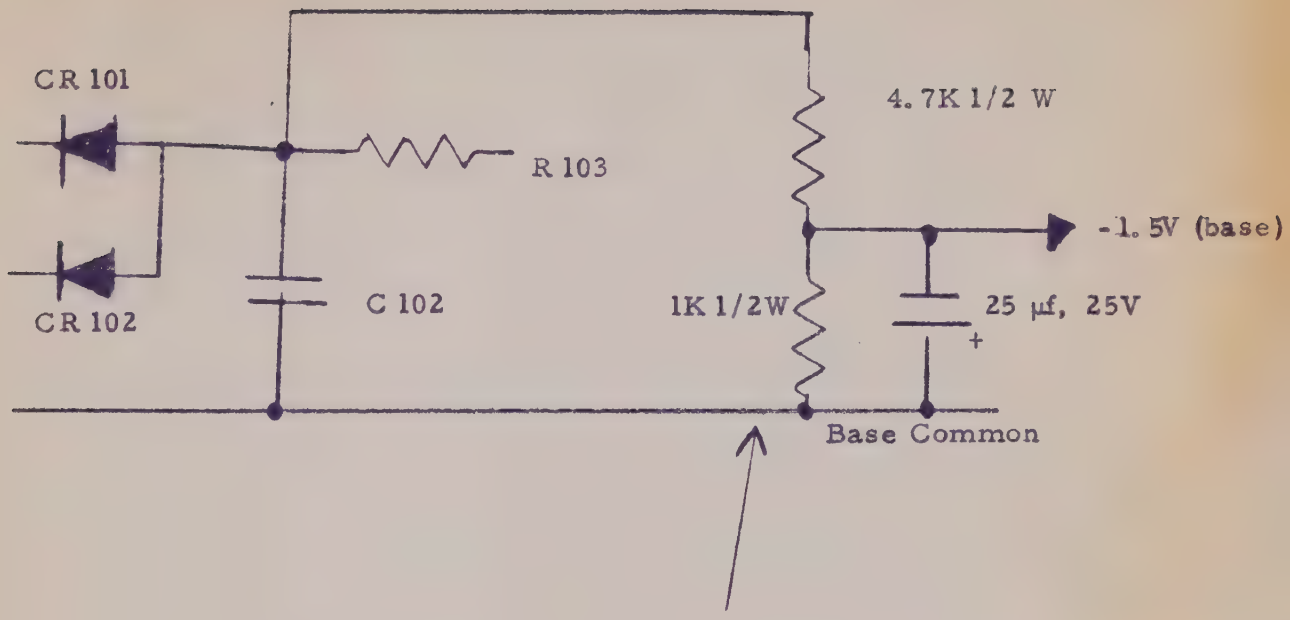


Present Wiring



Changes for Improving Saturation Measurements

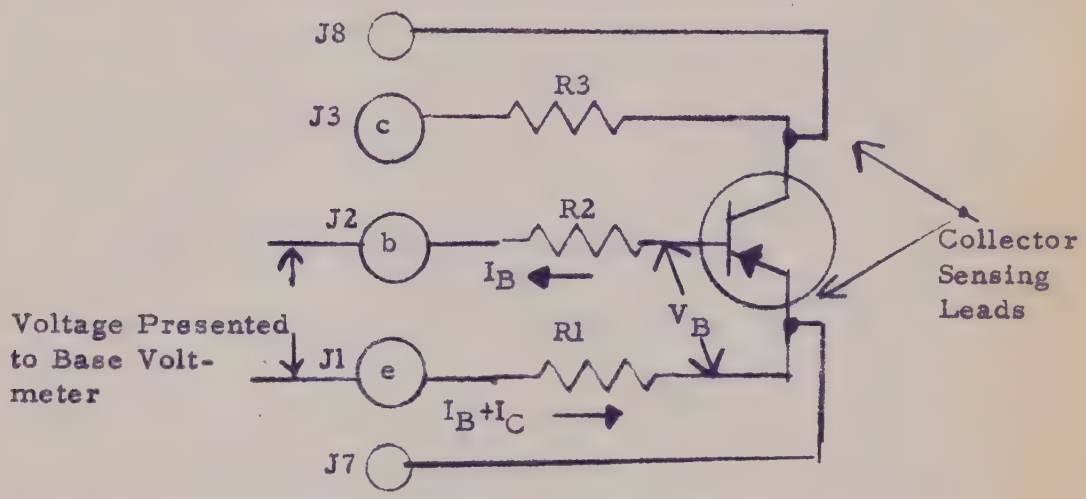
See next page for details of obtaining -1.5V (Base).



These new components should be added on the terminal board near C 102.

4) Base Voltage Measurements

Base to emitter voltage measurements in this series of instruments is measured right at the front panel jacks J1 and J2. Lead resistance between these jacks and the test transistor may introduce an error in measurement of base voltage, particularly at high emitter currents. A schematic of the measuring circuit and its sources of error is shown below:



R1, R2, and R3 represent the resistances of the leads from the front panel jacks to the transistor terminals. Since collector voltage is sampled right at the transistor via sensing Jacks J7 and J8, lead resistance errors are not a factor in measuring collector voltage.

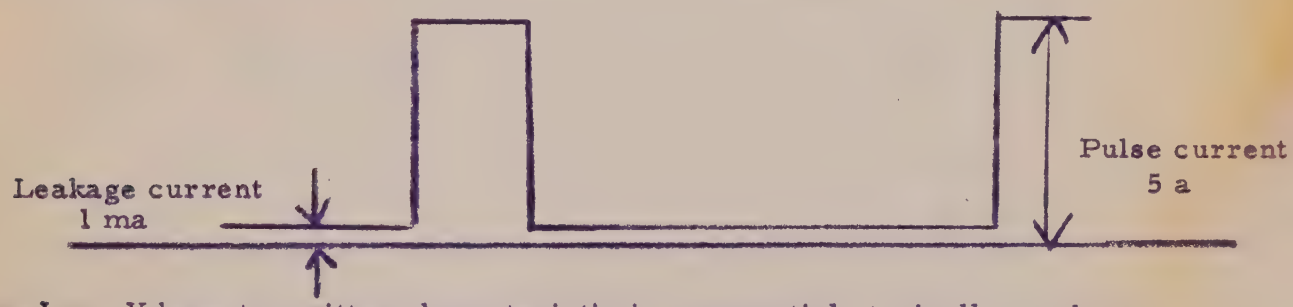
However, the base voltage is measured between Jacks J1 and J2. The true reading at the transistor, V_B, is the reading at the jacks minus the I_R drops is R1 and R2. Note that the drop in R1, the emitter lead, can be quite large since the emitter current can be 10 to 100 times the base current. As an example, number 10 wire has a drop of 50 MV/ft at the 50A current level. Accordingly, voltage drops in the test leads must be considered in measuring base voltage.

NC-1 APPLICATION BULLETIN #4

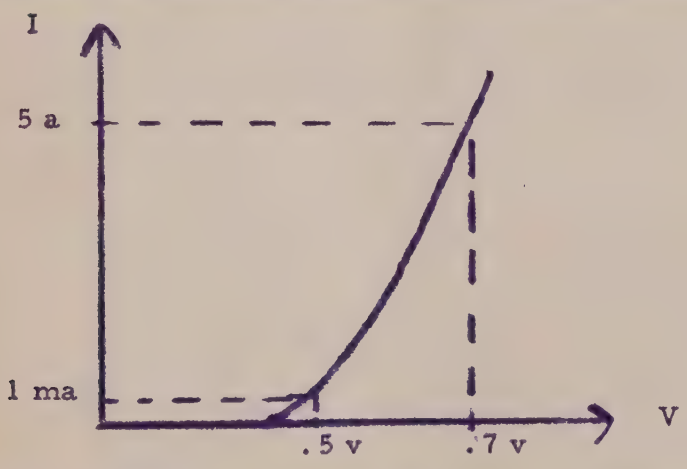
Base Current Generator Modifications to Improve V_B Accuracy

A customer has pointed out that under certain conditions leakage current in the base supply may cause a serious error in themeasurement of V_B. We have investigated these conditions and as a result are suggesting a simple modification that will eliminate this trouble.

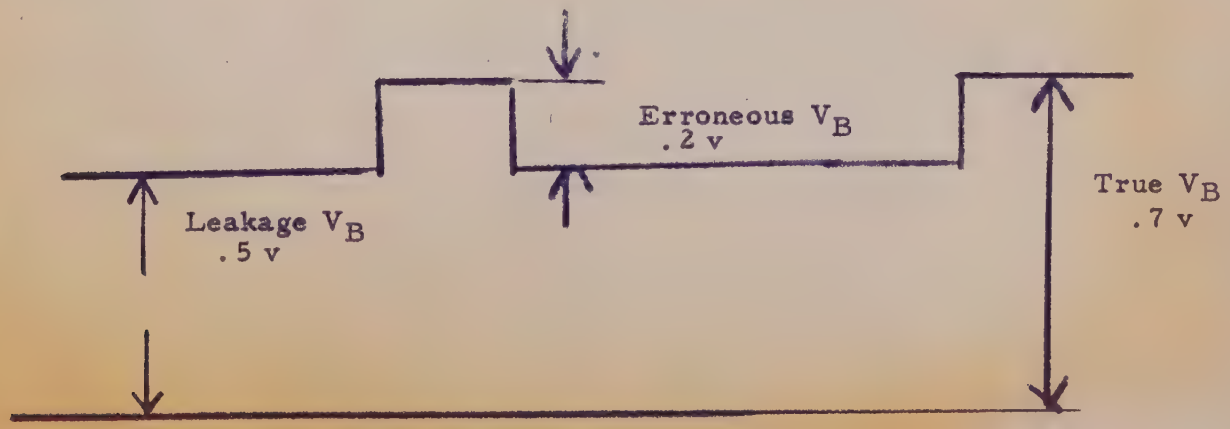
The base current generator has a very small DC leakage current that is caused by I_{CO} of the driver transistor. As a result of this, the base current signal is of the following form:



The I vs. V base to emitter characteristic is exponential, typically as shown:



Because of this logarithmic characteristic, the behavior of base-emitter voltage is as follows:



Our base voltmeter is AC coupled and responds to the peaks above the DC level which is unfortunately not zero. Although the numbers in the illustrative example are exaggerated, they do show what could happen under extreme conditions.

Our solution to this problem involves the following steps:

1. Rewiring Q204 on a 5 amp range so that effects of its leakage current are minimized.

2. Bypassing leakage current around the V_B junction by use of low impedance DC paths.

A marked up schematic is enclosed and shows how these changes can be made. There are sufficient spare terminals on the base generator and power supply wiring boards to mount the two resistors.

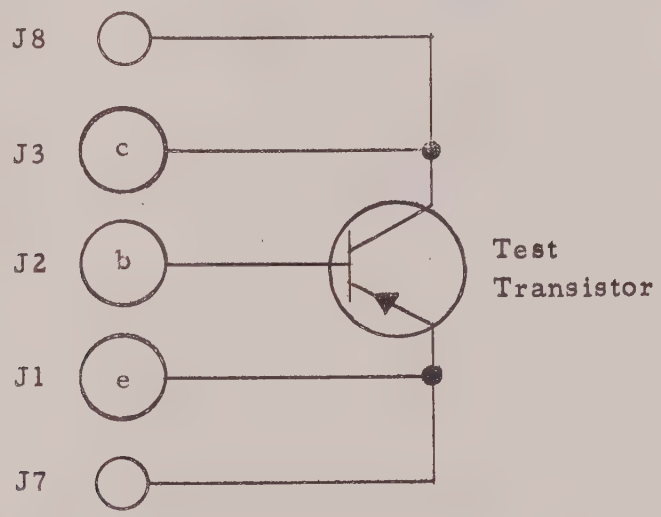
These changes with those of Bulletin #3 will upgrade all the earlier units (Serial 101-120) to current production.

NC-1 APPLICATION BULLETIN NO. I

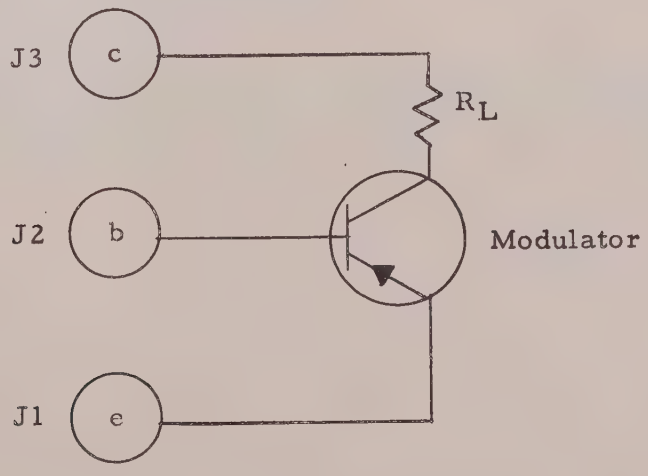
Diode Forward Drop Measured by the Pulse Method

By use of a suitable external transistor, the NC-1 may be used to measure forward drop of diodes up its 50 ampere capability. The power savings are very impressive - typically device dissipation can be held to 2% of the dissipation that would result if steady or unfiltered DC were used.

The basic test circuit for the diodes is derived as follows. The basic NC-1 power transistor connections are made as shown.



In this mode of operation the transistor current is a series of narrow pulses at 60 CPS repetition. If a load were placed in the collector circuit, then the combination of NC-1 and external transistor (called the modulator) could be used to supply pulse load currents to any external load. In this type of operation the NC-1 and suitable external transistor have the properties of a pulse modulator.



In particular, the external load can be a diode operated in the forward direction as shown:

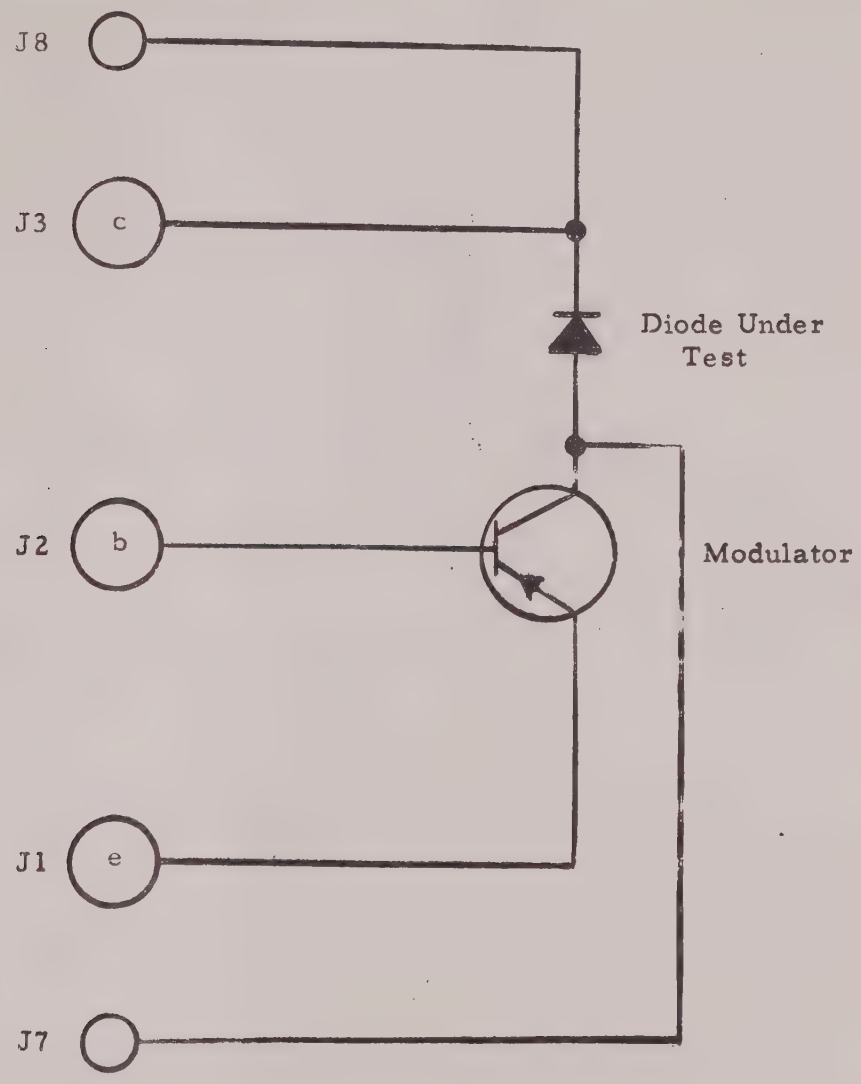


Figure 1 PNP Modulator

By using the jacks J7-8 as the inputs of a peak reading voltmeter, then the peak forward drop can be measured. The peak forward currents are measured on the usual collector ammeter since the modulator transistor and test diode have the same series current.

The connections for an NPN modulator are :

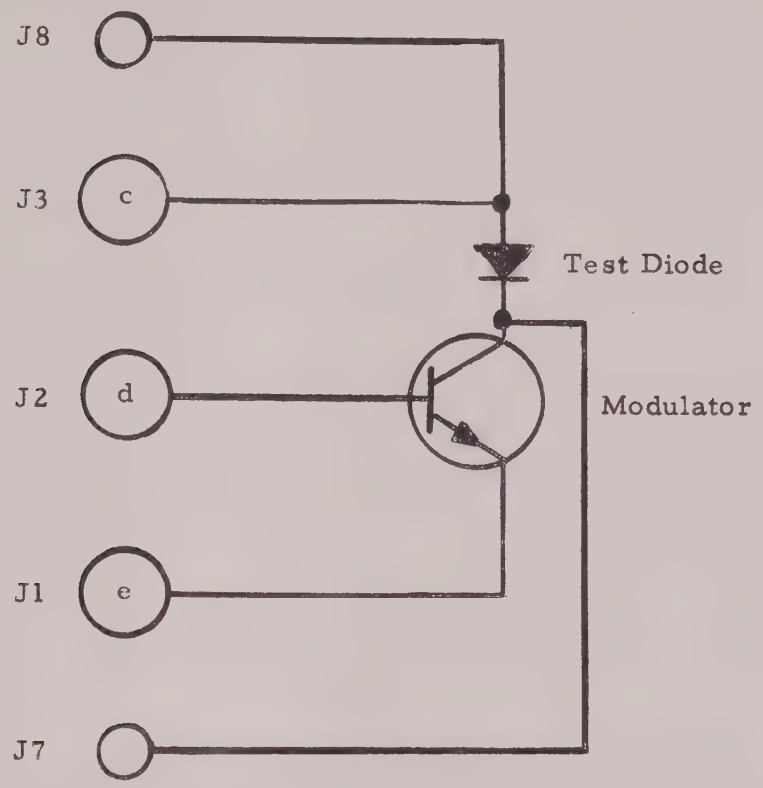


Figure 2 NPN Modulator

The requirements for the modulator transistor are not too critical. They are listed as:

1. Either PNP or NPN may be used, Germanium or Silicon.

2. The modulator transistor should be able to handle the required peak current and supply voltage.

3. In order to keep modulator dissipation low, the whole collector supply appearing across modulator and load should be kept small; typically 10 V is adequate.

4. Leakage current of the modulator should be kept as small as possible compared with the forward capability of the diode under test.

5. The full current capability of the NC-1 (up to 50 amperes) may be used.

A typical step-by-step procedure is given as follows:

a. The modulator transistor and diode to be tested are connected as shown in figure 1 or 2.

b. The collector supply is set to 10 volts (use V_{CO}-V_{EO}) meter selector position.

c. The base drive control is adjusted for appropriate collector current in the modulator transistor and load (use lowest range possible to minimize leakage).

d. When the desired current is set, forward drop is read on the V_C scales. (Connect sensing leads as shown in figure 1 or 2.)

(NOTE: When forward pulse current is zero, the voltmeter may show a reading of a few tenths of a volt. This is caused by leakage current flowing through the modulator and diode load. When pulse current is applied, the voltmeter should rise and correctly peak detect maximum forward drop at peak current. This may be verified with an oscilloscope with a direct coupled input.)

The case size of many diodes is large enough so that no heat sink is required for these pulsed forward tests; each individual case should of course be investigated.

Other NC-1 applications utilizing an external modulator will be discussed in future application bulletins.